THE EFFECTS OF CLIMATE CHANGE ON SHORT-TERM INSURANCE CLAIMS IN SOUTH AFRICA

by

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DECLARATION

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I declare that the dissertation/thesis entitled "**The effects of climate change on short term insurance claims in South Africa**" is my own work and that all sources used or quoted have been indicated and acknowledged by means of complete references.This work has not been submitted before in whole or in part application for any other degree or professional qualification.

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DEDICATION

I would like to thank the almighty God for blessing me with the resources, strength, and ability to do this study. I would like to express my deepest gratitude to my family for their support. I dedicate this dissertation to my husband Charles and daughters (Michelle and Samantha), who believed in me and endured time without me while I was writing up this dissertation.

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ABSTRACT

Climate change has become one of the most debated environmental risks. The world is faced with the threat of weather variability. There has been an increase in the frequency and severity of extreme weather events. There is rising concern that weather losses might affect the sustainability of insurance businesses. The primary obective of the study was to ascertain the significance of changes in temperature, precipitation and wind speeds in explaining changes in weather-related claims.Furthermore the reseach had three key secondary objectives, firstly to find if changes in annual average temperature levels lead to changes in weather-related claims. Secondly to determine if average annual wind speeds lead to changes in weather-related loss .Thirdly to establish if the average changes in annual rainfall or precipitation levels lead to changes in weather-related claims. Quantitatively this study explored the relationship between climate change and weather losses in South Africa. Temperature, rainfall, and wind speed were the main weather variables analysed. Lack of properly recorded insured weather losses was the major challenge. Nonetheless, total economic weather losses were used as a proxy for insured weather losses.The analysis employed regression, cointegration and vector error correction models. Study findings showed that climate change is influencing weather losses. The existence of correlation and causality between weather variables and losses was also affirmed. Thus the insurance industry should comprehensively incorporate climate change into its business strategy to minimise exposure.

Key terms: Weather-related losses; weather damages; economic weather losses; insured weather losses; climate change; short-term insurance; insurance claims; insurers; temperature; rainfall; wind speed; risk and emerging risks

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LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
BAAM	Business Adopt-a-Municipality
BFAP	Bureau for Food and Agricultural Policy
COP17	17th Conference of the Parties
CSIR	Council for Scientific and Industrial Research
ENSO	El Niño Southern Oscillation
FAIS	Financial Advisory and Intermediary Service Act
FSB	Financial Services Board
GDP	Gross Domestic Product
IPCC	Intergovernmental Panel on Climate Change
NASA	National Aeronautics and Space Administration
NatCatService	National Catastrophe Service
PwC	PricewaterhouseCoopers
R^2	R-squared
UCS	Union of Concerned Scientists
UCT	University of Cape Town
UNEP	United Nations Environmental Programme

UNEPFI	United Nations Environment Programme Finance Initiative
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations International Children's Emergency Fund
VECM	Vector Error Correction Model
WWF	Worldwide Wildlife Fund

CHAPTER 1: INTRODUCTION TO THE STUDY

1.1. Introduction

The devastating effects of weather-related damages have been reported and recorded throughout the world. There has been a global rise in the average weather-related losses. Similarly, South Africa has also been confronted with weather-related damages in the last decades. The frequency and intensity of these weather calamities are expected to increase as a result of climate change (Ward and Ranger, 2010). The increase in these catastrophes is likely to have negative effects on economies, societies, and businesses. For these communities to be able to tackle these increasing fortuitous events, the association between climate change and weather losses should be thoroughly understood. Therefore, the aim of this study is to establish if climate change events have a relationship with weather-related losses that have been observed in South Africa. The study will focus on the short-term insurance industry, which is often the direct and indirect recipient of weather losses. This chapter will present the background of the phenomenon, research purpose, statement of the problem, research objectives, hypotheses and significance, limitation, and assumptions of the study.

1.2. Weather-related Loss: An Overview

The worldwide average annual weather-related losses in both developing and developed countries have increased in the last decade (Federal Ministry for Economic Cooperation and Development, 2015). In 2015, global economic losses were mainly a result of floods, thunderstorms, cyclones, hurricane droughts, heat waves, and fires. These weather-related events contributed 70% to global natural disaster losses (Aon Insurance Brokers, 2016b). Insured weather-related losses have also been on the rise in the last three decades. This trend is expected to accelerate if climate change continues to influence the frequency and severity of these weather-related events (Zurich, 2009). The economic and financial costs of these events can have a profound burden on societies and communities; hence, insurance remains a key tool for managing climate risks to reduce vulnerability (Lashley, 2012). Climate risk insurance remains a crucial climate risk management vehicle, as it provides peace of mind and financial protection to weather-affected individuals or businesses (Surminski, Bouwer & Linnerooth-Bayer, 2016; Mills, 2005).

Several reports from local insurers have revealed that the industry has become increasingly exposed to weather risks. The effects of climate change are becoming more evident in the form of devastating hailstorms, increase in temperature, droughts, fires, floods, and rainfall variability in South Africa. Short-term insurance industry analysts have documented that the local industry has already registered a significant increase in weather-related payouts (KPMG, 2013). Climate change is viewed as the main contributor that is exacerbating adverse weather conditions, and it is projected to increase the frequency and severity of weather events in South Africa (Ziervogel, New, Archer van Garderen, Midgley, Taylor, Hamann, Stuart-Hill, Myers & Warburton, 2014). Weather disasters such as floods, droughts, and hailstorms can cause widespread destruction of the insured property and assets. If climate change continues to increase the intensity and frequency of these destructive weather events, short-term insurers as direct assumers of such risks are likely to be affected.

1.3. Background of the Study

Changing weather patterns have become a global issue, and they been a subject of discussion both internationally and locally. Globally, average land and ocean surface temperature has increased by about 0.65 to 1.06°C from 1880 to 2012 (Intergovernmental Panel on Climate Change [IPCC], 2013). The climate change conference (COP21, 2015) brought to light the urgent need amongst governments to come up with a legally binding and universal climate agreement. Members acknowledged climate change recommendations from world scientists such as the IPCC and agreed that global warming should be kept below 2°C from pre-industrial levels in order to combat climate change.

There is consensus amongst leaders of scientific organisations that climate change is occurring and has become a global problem. Scientific research conclusively shows that human activities are influencing climate change (American Association for the Advancement of Science, 2009). The average atmospheric temperatures are rising due to human activities that are causing increased concentration of greenhouse gases (IPCC, 2007). If no mitigation to reduce greenhouse gases is taken, it is predicted that global warming is likely to worsen climate change and adverse weather patterns in the 21st century (IPCC, 2014a).

Furthermore, climate change is predicted to shift weather patterns, thus influencing both precipitation and temperature. This shift in weather patterns has been described as the source of climate change that is causing some regions to experience higher or lower precipitation events while others experience warmer temperatures (Federal Ministry for Economic Cooperation and Development, 2015). Modern normalisation analysis methods show that there have been statistically significant increases in unfavourable weather-related events in the past three decades (Ward and Ranger, 2010). These events have caused unprecedented loss of life, assets, property, and crops. That being the case, the need to respond to these climatic risks to reduce vulnerability has become urgent than ever before. Insurance has been used for decades as an ex-ante risk management tool against weather-related risks (Surminski and Oramas-Dorta, 2013). It still remains the critical method to mitigate and respond to weather-related damages.

Insurance provides a vehicle for transferring the cost burden of risk rather than the transfer of the risk itself (Valsamakis,Vivian & Du Toit, 2010). With that said, insurance is a risk management instrument that provides protection from financial loss. Extreme climatic events cause losses and damages that translate into insurance claims for insurance companies. For example, when an insured building or a vehicle is damaged by floods or hailstorm, the financial cost of the loss is transferred to the insurance company. To illustrate the importance of insurance, it has been observed that global economic losses from weather-related events have risen in real terms in the period between 1980 and 2009 (Ward and Ranger, 2010). A World Bank report in 2013, with research done by Munich Re, showed that world weather-related losses have increased from an annual average of US$50 billion in the 1980s to about US$200 billion over the last decade (Primer, 2013). Comparably, global insured weather losses for the same period have also increased (IPCC, 2012).

The insurance sector continues to bear the effects of climate change and extreme weather events (Maynard, 2008). Insurers continue to experience a significant increase in property claims and costs of weather-related losses (Mills, 2007a). The industry has been incurring major weather-related losses which can have detrimental effects on its financial and growth capacity (Lloyds, 2014; Mills, 2005). Weather-related events affect almost all types of insurance classes such as cars, property, liability, agriculture, and marine (Mills, 2005). Climate change has both positive and negative impacts on the insurance business, with a strong trend towards net negative effects (Mills, 2003). If climate change-related damages continue to rise, insurers may face the prospect of an increase in claims payouts (Schiller, 2012). Increased losses put pressure on insurer pricing, portfolio values, and solvency (Mills,Lecomte & Peara; 2001). In view of the costliness of weather damages, the insurance sector lobbied governments to take action against climate change in the run-up to the United Nations climate summit in Paris (Gould, 2016).

Projections for South Africa also show that the country's exposure to weather-related events is likely to increase. The International Energy Agency projected that South Africa is likely to experience a long-term global temperature rise of 3.5°C, leading to increasing extreme weather events and rising sea levels (KPMG, 2012). The local short-term insurance industry has already begun experiencing a substantial number of weather-related claims due to severe hailstorms, droughts, and flooding. Industry players, representative organisations, and weather scientists have also begun engaging in serious discussions and debates regarding climatic risks. In a forum held in 2014, stakeholders concurred that the impact of climate change had become evident and common in South Africa (South African Insurance Association & Insurance Institute of South Africa, 2014).

1.4. Research Problem

Climate change has become the top pressing universal problem (Prowse, 2010). The world is confronted with the undeniable threat of increasing climate variability. In the period between 1994 and 2013, it is estimated that worldwide losses of US$2.17 trillion were incurred as a result of over 15,000 extreme weather events (Kreft, Eckstein, Junghans, Kerestan & Hagen, 2014). Climate change is predicted to increase the occurrence of adverse weather conditions leading to an increase in weather disasters.

The consequences of weather events are now tangible and visible through destructive storms, floods, droughts, and hurricanes that are occurring. In the past decades, these weather events have accounted for more than half of global insured losses (Madrid, Frankfurt & Glass, 2015). The 10-year rainfall intensity in South Africa is estimated to have increased by 10% (Mason, Waylen, Mimmack, Rajaratnam & Harrison, 1999). There has been a noteworthy increase in severity and frequency of weather-related events in the last decade. Locally, it was estimated that damage costs due to weather-related events in South Africa could have been R1 billion per annum between 2000 and 2009 (17th Conference of the Parties [COP17],Govender, 2011; Lange, 2011).

The frequency and severity of floods and storms damaging property worth billions of rands have increased over the years. In February 2015, Kimberley in the Northern Cape experienced more than 100 mm of rain in less than one hour, resulting in flash floods that caused extensive damage to vehicles, houses, and businesses (Santam, 2015). Extreme hot temperature conditions were experienced across South Africa in 2015. The severe drought conditions and wildfires destroyed property, animals, and crops, and damages to the agricultural sector in the Western Cape province was estimated to be R4 billion (Aon Insurance Brokers, 2016a). These weather costs have become a major issue of concern to the short-term industry because these changing weather patterns are influencing weather-related losses or claims consequently paid out by insurers.

Weather-related catastrophes have been identified as key climate change risks in South Africa that should be proactively managed to ensure business sustainability (Santam, 2012). Santam paid out almost R280 million towards hail damage claims in 2012 compared to the 10 year highest of about R50 million incurred in 2004 (Santam, 2012). Standard Bank Insurance experienced about a 402% increase in storm-related claims for March 2014 (Standard Bank Group, 2014). The local industry received 56% more weather claims in March 2014 compared to March 2013 (Hofmeyr, 2014). A report by Lion of Africa Insurance indicated that the South African insurance industry is already experiencing the effects of climate change and rainfall variability. In 2015, droughts, heat waves, fires, electrical and lightning damages or losses led to increases in claims, while in the past four years, the industry experienced severe storms that cost the industry significantly (Lion of Africa, 2016). Another report by Outsurance revealed that short-term insurers experienced a remarkably high number of weather-related property claims in July 2016. Furthermore, there was a tornado which caused extensive damage to a shopping mall east of Johannesburg. Outsurance was the insurer for one of the shops that were destroyed (Outsurance, 2016).

This shows that the short-term insurance sector is exposed and vulnerable to climate change damages. Although climatic risks are still new, the insurance industry has knowledge of these risks (Odeku, 2012). Moreover, if the aforementioned trends are carefully considered, they demonstrate that the insurance industry in South Africa, similar to in other countries, is also exposed to catastrophic weather events. These catastrophic events can lead to an increase in large and unanticipated insurance claim payouts with the potential of reducing the industry’s capital reserves and profitability. Although there are limited scientific studies done in South Africa that link climate change and short-term insurance weather claims in South Africa,emprical studies carried out in other countries show that there is a connection between change in climate and short term insurance weather losses.

A study examining the effects of weather events on loss ratios for crop insurance products was conducted in New Jersey. It revealed that changing weather patterns can result in an increase in insurance payouts in weather-sensitive sectors such as agriculture. In addition, the investigation established that there is an association between changes in weather variables (drought, cold weather, and excessive rainfall) and crop insurance losses. The study confirmed that increasing incidences of insurance losses could be attributed to increased climate variability (Mafoua and Turvey, 2004).

A study of a similar nature – similar to the foregoing study – is important for the South African insurance sector to also verify if climate change is influencing weather-related losses. There have been vibrant industry debates and theories linking climate change and insurance claims in South Africa, but no scientific study has been carried out to establish the effects of climate change on the industry. Systematically, it remains unanswered whether increasing weather loss ratios that the industry is experiencing are a result of climatic variability or other causes such as adverse selection and moral risk. In light of that, this study will seek to establish if there is a possible relationship between climate change and insured weather losses in South Africa.

1.5. Research Purpose

The critical role of facilitating recovery and resilience played by the insurance industry in the economy makes it so important to undertake this study. By providing risk management solutions to other economic agents, the insurance industry ensures that economies grow and can be resuscitated in the event of destruction or damages from climate change risks (Mills, 2009). An increase in costs of weather damages can affect the affordability, availability, viability, and sustainability of short-term insurance services. Therefore, it was imperative to study the relationship between climate change and weather-related losses in an environment where weather-related damages are purported to be increasing as a result of adverse weather conditions. Furthermore, the importance of insurance and lack of similar scientific research in the industry makes this study more useful in guiding future studies.

1.6. Research Objectives

The primary objective of this study is as follows:

- To ascertain the significance of changes in temperature, precipitation and wind speeds in explaining changes in weather-related claims

The secondary objectives of this study are the following:

- To find if average changes in annual temperature levels lead to changes in weather-related claims
- To determine if average annual wind speeds lead to changes in weather-related loss
- To establish if the average changes in annual rainfall or precipitation levels lead to changes in weather-related claims

1.7. Research Hypothesis

The following is the proposed hypothesis that will be tested in this study in an endeavour to fulfil the research objectives:

- H_o: There is a possible correlation between climate change and weather-related losses
- H_a: There is no correlation between climate change and weather-related losses

Criteria for decision:

Accept H_o and reject H_a if there is a significant relationship between climate change and weather-related loss ($p<0.05$)

Reject H_o and accept H_a if there is a significant relationship between climate change and weather-related loss ($p>0.05$)

1.8. Significance of the Study

The insurance industry is faced with direct and indirect effects of climate change. Climate changes have created an array of risks that insurers have to deal with. Insurers are yet to determine the extent of their exposure to the emerging climatic and weather risks (Mills, 2009). The industry's response has been more reactive than proactive, and some insurers have not fully embraced climate change (Mills,2007a). Insurance plays a key role in minimising the impacts of climate change. Changes in weather patterns threaten insurers with an increase in claims or losses from floods, storms, droughts, and heat waves. An increase in claims or losses from these events can cause financial shocks to the industry. Thus, understanding the effects of climate change on insurance claims can assist insurers to step up their efforts to match the emerging weather risks. This type of research could help insurers prioritise the fight against climate change and embed it in their enterprise risk management strategies.

The insurance industry has a crucial function to play in supporting economic development and financial cohesion. It provides a conduit for recovery from fortuitous events. Accordingly, the statistical findings could consequently draw the industry's attention on why they should incorporate climatic risks in their business models and spearhead implementation of effective risk management to mitigate the effects of climate change. This could encourage insurers to support research on forecasting of future weather patterns and collaborate with climate scientists to fight against climate change. This also seeks to challenge insurance players to facilitate and champion programmes that seek to reduce greenhouse gas emissions, and promote the use of efficient and clean energy. Research findings might help to improve industry collaboration with policymakers and encourage regulators to develop guidelines that ensure an increase in storm-resistant buildings.

1.9. Assumptions

The following assumptions were taken into account in designing and carrying out the research:

- Average climatic variables (average precipitation, temperature levels, and wind speed) will be used to provide a reflection of fluctuations in weather patterns over the years.
- Total economic losses from weather-related events will be used as a proxy for insured losses in this study. This will show the actual cost impact of climate change and what the insurance industry could incur if all the costs were insured.
- Gross written premium is a proxy or reflects insurance penetration or market growth.

1.10. Delimitations

The study will focus on the effects of climate change on short-term insurance weather-related claims/losses in South Africa from 1980 to 2015.

1.11. Limitations

The following were the limitations observed in carrying out the study:

- The 2016 weather-related losses data is not yet available. Data available is from 1980 to 2015.
- Establishing the effects of climate change on insurance claims and trends may be difficult due to lack of comprehensive and consistent recording of weather losses in the public domain. The data collection on weather losses is still poor in South Africa.
- The study used weather data from eight weather stations only, yet South Africa has several weather stations.
- This is still a new field of study; there is limited research done in the field of climate change and insurance in South Africa. Lack of econometric studies relating to the local industry that can be built on means that the attempt to establish the relationship between climate change and weather-related claims could be limited.

1.12. Definitions of Terms and Concepts

Table 1.1 defines some of the terms and concepts used in this study.

Table 1.1: Definitions Used in the Study

Term/Concept	**Definition**
Insurance	A risk management tool used to offer protection or compensation from financial loss. In exchange for a premium, the insurer promises to compensate the insured if the covered event occurs (IPCC, 2012 , Rani and Shanikar,2014)
Weather-related events	This mainly refers to floods, storms, drought, hail, heat waves, wind, and cyclone (Smith and Katz,2013)
Weather losses	Physical losses or costs that come through damages to property as a result of weather events (floods, storms, drought, and wind) Smith and Katz,2013)
Weather risk	Financial gain or loss as a result of changes in climatic conditions (Pezzoli.2013)
Economic loss	Total financial loss suffered by a nation from property damage, business disruption, and death or injury as a result of weather-related events,both insured and uninsured losses (Hallegatte, 2015, United Nations International Strategy Disaster Risk Management (UNISDR),2009)
Insurance claim	Notification and demand for payment or idemnification in accordance with an insurance policy,submitted to the insurer by the policy holder after the occurrence of an event (National Insurance Brokers Association (NIBA),2006)
Insurer	A party to an insurance arrangement or contract that undertakes to pay compensation or provide cover in the event of a loss (NIBA,2006)

Term/Concept	Definition
Insured losses	Weather losses that are covered by insurance, and the cost directly affect the financial exposure of the insurance industry (Monti, and Tagliapietra, 2009).
Climate change	The IPCC defines “climate change” as “a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer” (UNISDR,2009).
Climatic risk	Damages or losses as a result of weather events. Referes to the extent of exposure and vulnerability to weather events (Kreft, Eckstein, Junghans, Kerestan& Hagen, 2015)
Weather	The American Meteorological Society glossary defines weather as the state of the atmosphere, with respect to its effects upon life and human activities, and it is known in terms of temperature, humidity, precipitation, cloudiness, visibility, and wind (American Meteorological Society,1959)
Severe or extreme weather	Hydrometeorological events which can cause damages, destruction to property, and serious social and economic disruptions (UNISDR,2009)
Carbon emission	Carbon emission is the release of carbon gases (greenhouse gas) into the atmosphere. The greenhouse emissions from burning of fossil fuels are contributing to climate change (Ecolife Dictionary)
Short-term insurance	Short-term insurance policy refers to an engineering, guarantee, liability, miscellaneous, motor, accident, health, property or transportation or a contract comprising a combination of any of those policies which are renewed or varied (South Africa, 1998)

1.13. Structure of the Study

The study comprises five chapters, as shown in Table 1.2. This chapter provided a detailed overview or background of the phenomenon under study, defined the research problem, objectives, hypotheses and significance of the research. Chapter 2 contains extensively reviewed literature of existing theories, empirical evidence, and concepts regarding climate change and weather-related losses or insurance claims. Chapter 3 focuses on the research methods and designs that were used to conduct the study. Chapter 4 deals with results presentation, and a summary of findings and interpretation. Chapter 5 outlines the research implications, recommendations, and suggestions for further research.

Table 1.2: Organisation of the Study

Chapter 1	• Introduction
Chapter 2	• Literature Review
Chapter 3	• Research Methodology
Chapter 4	• Results Presentation and Analysis
Chapter 5	• Recommendations and Conclusion

1.14. Summary

The information provided in Chapter 1 reveal that there is consensus that climate change is a problem that is influencing weather-related losses globally and in South Africa. Furthermore, the local short-term insurance industry indicated that it is becoming increasingly exposed to weather risks. Accordingly, the core of this study is to test the credibility of the industry's debate that climate change is influencing weather-related losses.

In view of the foregoing, the next chapter will provide comprehensive and extensive literature on causes, effects, and trends of climate change on weather losses on the short-term insurance industry in both global and local context. Furthermore, empirical evidence of similar studies conducted in other countries will also be reviewed.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

Climate change has been a subject of discussion by historians, policymakers, and scientists since medieval times (Stahel, 2009). In recent times, it has also become one of the most debated environmental issues. Scientists, governments, and business leaders have attributed the increasing incidents of extreme weather-related events to climate change. Some of the adverse weather conditions that have been linked to climate change are storms, floods, cyclones, droughts, strong winds, and hail. Despite concrete scientific evidence that climate change is real, some governments and communities have been slow in taking appropriate action against it. Policymakers should seriously consider climate change when making policies and act against it with certainty (National Aeronautics and Space Administration [NASA], 2016). This lack of proactive interventions to counter climate change and reduce its impacts continues to expose societies to extensive damage of property and assets as a result of adverse weather conditions.

The consequences of unfavourable weather conditions are becoming more common and presenting significant challenges to financial markets such as insurance and risk management. Climate change risk is now viewed as the fourth serious problem facing the insurance sector. Patterns indicate that losses are increasing by 37% every 10 years, and that payouts towards extreme weather losses could reach US$400 billion to US$1 trillion per year (Mills, 2009). In light of this, there is growing recognition amongst some insurers that the effects of climate change on future losses could be profound. If these weather-related losses are not properly predicted and accounted for, this could spark financial crisis in insurance markets. Financial reserves held to meet claims could dwindle due to an increase in unexpected weather claims (Maynard, 2008). Furthermore, insurers are likely to be faced with diminishing profits, increase in liabilities and capital requirements which if not properly anticipated might negatively affect their business models (Prudential Regulation Authority,2015).

In view of these possible effects of weather-related damages on the insurance industry, study objectives and purpose were outlined in the previous chapter. This chapter contains a review of literature relevant to this study. This will extensively evaluate and explore the subject of climate change and insurance in order to understand the phenomenon. Additionally, the chapter will provide an in-depth synthesis and analysis of the following causes of climate change: the effects of climate change on weather-related events, observed trends, and weather damages on short-term insurance losses in the global and local context. Previous pieces of research or empirical studies undertaken in other countries on the effects of climate change on insurance claims will also be reviewed.

2.2. Causes of Climate Change

Climate change is attributed directly or indirectly to human activities that alter the composition of the global atmosphere and to natural climate variability observed over a comparable period (United Nations Framework Convention on Climate Change [UNFCCC], 1992). Weather is the state of the atmosphere with respect to its effects on life and human activities, in terms of temperature, humidity, precipitation, cloudiness, visibility, and wind (American Meteorological Society,1959). Climate change influences change in the frequency, intensity, distribution, and variability of weather events. Climate change is caused by natural and human factors. Natural causes are recurring forces that have been around for millions of years, while anthropogenic activities are recent human activities (Thompson, 2010).

2.2.1.Natural Causes of Climate Change

The earth's climate is dynamic and naturally variable. It can be affected by natural factors, such as changes in volcanic activity and emissions, continental drift, solar output or irradiance, and the earth's orbit or oscillations around the sun. Variability in these factors can change global temperatures and global climate systems (Ring, Lindner, Cross & Schlesinger, 2012; Canada Action on Climate Change, 2013). Although climate varies naturally, scientists concur that the current warming trends cannot be accounted by natural forces only (Keller, 2003, Schmidt,2009). Some of the natural causes of climate change include continental drift, volcanoes, earth's tilt or orbit, variation in solar output, and distance from oceans.

Continental drift is when land masses gradually shift apart over the years. The separations result in a changing of position and physical features of land masses. The separations also lead to changes in the flow of air, ocean currents and winds affecting the climate. Scientists believe that continents found on the earth today were formed when the land mass began gradually drifting apart, some millions of years back. This drift also had an impact on the climate because it changed the physical features and position of the land mass and water bodies. The drift of the continents continues even today; the Himalayan range is rising by about 1 mm every year because the Indian land mass is moving towards the Asian land mass (Khan, 2012).

Volcanic eruptions affect global temperature circulation and the global climate system (Langmann, 2014). Volcanic events lead to increase in sulphate aerosols loading in atmosphere (Santer, Bonfils, Painter, Zelinka, Mears, Solomon,Schmidt, Fyfe. Cole, Nazarenko, Taylor and Wentz,2014). Volcanoes throw out large volumes of sulphur dioxide (SO_2), water vapour, dust, and ash particles into the atmosphere, which can influence climatic patterns. For example, the fine ash from the 1883 explosion of Krakatoa was blown around the world and caused exotic sunsets and other climatic effects. These gases and dust particles partially block the incoming rays of the sun or reduce the amount of solar radiation reaching the earth's surface. By blocking solar radiation, this diminishes or lowers temperature levels of the atmosphere, thus leading to cooling and change atmospheric circulation patterns (McCormick,Dutton & Mayewski, 2007; Andersson, Martinsson, Vernier, Friberg, Brenninkmeijer, Hermann, Van Velthoven, and Zahn, 2015).

The earth's orbit is elliptical, meaning that the distance between the earth and the sun varies over the course of a year, which can ultimately affect the distribution of solar energy. The proximity to the equator also affects the climate of a place. Equatorial regions receive more incoming solar radiation throughout the year compared to poleward regions. The gradual change in the direction of the earth's axis, known as precession, is responsible for changes in the climate. The earth makes one full orbit around the sun each year. It is tilted at an angle of 23.5° to the perpendicular plane of its orbital path. For one-half of the year in summer, the northern hemisphere tilts towards the sun. In the other half when it is winter, the earth is tilted away from the sun. If there were no tilt, seasons would not be experienced. Changes in the tilt of the earth can affect the severity of the seasons; more tilt means warmer summers and colder winters; less tilt means cooler summers and milder winters (Thompson 2010, Haigh, 2011 Khan, 2012).

The Milankovitch theory also suggests that normal cyclical variations in the earth's orbital characteristics might be responsible for some past climatic changes. The theory assumes that over time, these cyclical events vary the amount of solar radiation that is received on the earth's surface (Zhang, Wang, Hammarlund, Wang, Costa, Bjerrum, Connelly, Zhang, Bian & Canfield, 2015; Bast, 2010).

Some scientists were of the view that the sun's output radiation varied by only a fraction of a percentage over many years. Studies and measurements made by satellites equipped with radiometers in the 1980s and 1990s suggested that the sun's energy output may be more variable. Numerical climate models predict that a change in the solar output of only 1% per century would alter the earth's average temperature by between 0.5 to 1°C. It was noted that if this trend was to go on over several decades, it could influence global climate (Pidwirny, 2013; Onoja,Dibua and Enete, 2011).

Oceans are also a significant component of the climate system. They cover about 71% of the earth and absorb about twice as much of the sun's radiation as the atmosphere or the land surface. Coastal areas are cooler and wetter than inland areas. Certain parts of the world are influenced by ocean currents more than others. Ocean currents can increase or reduce temperatures (Bigg, Jickells, Liss, and Osborn, 2003,Smith, Dubois, and Marotzke, 2006,Sharma, 2014). Oceans also transport and redistribute heat around the globe.These water bodies also absorb some of the heat produced on the earth system due to climate(Whitmarsh, Zika, and Czaja, 2015).

Although the earth's climate is always changing through the natural cycles, the degree and patterns of current warming cannot be explained by natural factors alone. Climatologists are in agreement that the warming trend for the past 100 years cannot be accounted by natural forces only (Thompson, 2010). Changes in socio-economic factors such as industrialisation, population growth and concentration, consumerism, technology, increasing wealth, and environmental degradation have accelerated climate change. There is compelling evidence that the increase in greenhouse gases released into the atmosphere by human activities are causing climate change and global warming. Therefore, human causes of climate change will be reviewed next.

2.2.2.Human or Anthropogenic Causes of Climate Change

Climate change is undeniable (Furberg,Evengard and Nilssoon, 2011). Observations have shown that over the past five decades, human-induced emissions have influenced climate change (Karl, 2009). Gases from combustion of fossil fuels, coal, oil, and use of cars, factories, electricity production and agriculture are contributing to global warming. These greenhouse gases have different heat-trapping capacities, and re-emission of longwave back to the earth's surface increases the quantity of heat energy (IPCC,2007 ,Stephenson, Newman & Mayhew, 2010; Khan, 2012; IPCC, 2014b). Human activities result in anthropogenic emissions of these gases that are accumulating in the atmosphere and increasing concentration with time. Massive increases in these gases have occurred in the industrial revolution era due to increasing production. Emissions are expected to increase considerably in the absence of a stringent climate policy agreement as a result of rapid economic development in emerging countries (Botzen and Van den Bergh, 2008).

2.2.3.Greenhouse Gas Effect

Evidence based on scientific evidence shows that climate change and global warming is mainly a result of anthropogenic factors. Greenhouse gas concentration creates an insulation blanket on the earth's surface, thereby preventing infrared radiation from escaping back into space (Prowse, 2010). Greenhouse gas concentrations in the atmosphere have increased by 40% since 1850. Carbon, methane, halocarbons, and nitrous oxide are at levels unprecedented in at least 800,000 years. Water vapour is also the most abundant and dominant greenhouse gas in the atmosphere (IPCC, 2014b). In view of the foregoing, it appears anthropogenic activities have become more important in explaining current and future climate change than possible changes in natural processes of the earth.

Studies of long-term climate change found a connection between the concentrations of greenhouse gases in the atmosphere and mean global temperatures. The re-emission of longwave back to the earth's surface also increases the quantity of heat energy in the earth's climatic system. Without the greenhouse effect, the average global temperature of the earth would be a cold -18° rather than the present 15° (Bast, 2010). Anthropogenic activities have played a considerable role in influencing climate risks and the magnitude of impact. Scientific studies suggest that if emissions continue unmitigated, climate change is likely to continue (Stern, 2007). It is also important to understand that greenhouse gases emitted into the atmosphere today will influence the atmospheric concentration for centuries to come (Watson, Rodhe, Oeschger, and Siegenthaler,1990). Some of the noteworthy and principal greenhouse gases that have largely contributed to global warming and climate change will be explored next.

2.2.2.3.1. Carbon Dioxide

The increase in the production of fossil fuels as a result of burning power plants, transportation, building heating, cooling, and the manufacture of cement and other goods have led to increased carbon dioxide emissions. For example, the generation of electricity from coal-burning power plants releases enormous amounts of carbon dioxide into the atmosphere (World bank 2008,Qader,2009, Akpan, and Akpan,2012). Population growth and increasing demands for consumer goods are also influencing the increase in the use of fossil fuels, thus leading to an increase in carbon dioxide emissions (Mohiuddin, Asumadu-Sarkodie, and Obaidullah, 2016).

2.2.2.3.2. Methane

Atmospheric gases such as water vapour are also able to alter the energy balance of the earth when they absorb longwave radiation emitted from the earth's surface (Bast, 2010). Methane is produced when organic matter is broken down by bacteria under oxygen-starved conditions. Methane has also been observed to be another potent greenhouse gas contributing to climate change. Methane gases have also increased as a result of human activities related to agriculture, natural gas distribution, and landfills. It is also released from natural processes that occur in wetlands. Methane production can also take place in the intestines of herbivorous animals, and with the increase of concentrated livestock production, the levels of methane released into the atmosphere are increasing (Watson, Rodhe, Oeschger, and Siegenthaler,1990,National Research council, 2010).

2.2.2.3.3. Nitrous Oxide

This gas is also emitted from human activities such as fertiliser use and fossil fuel burning. Natural processes in soils and the oceans also release nitrous oxide. The use of chemical fertilisers and nitrogen-rich fertilisers as opposed to the use of animal manure has risen. The high usage rate has an effect on the heat storage of cropland, as nitrogen oxides have 300 times more heat-trapping capacity per unit of volume than carbon dioxide (Watson, Rodhe, Oeschger, and Siegenthaler,1990,IPCC, 2007).

2.2.2.3.4. Water Vapour

Water vapour is one of the most abundant and important greenhouse gases in the atmosphere. Human activities have only a small direct influence on the amount of atmospheric water vapour. However, indirectly humans have the potential to affect water vapour substantially through methane emissions because methane undergoes chemical destruction in the stratosphere, producing water vapour. A warmer atmosphere also contains more water vapour (IPCC, 2007).

2.2.2.3.5. Aerosols and Halocarbon

Aerosols are small particles in the atmosphere with widely differing sizes, concentration, and chemical composition. Some aerosols are emitted directly into the atmosphere, while others are formed from emitted compounds. They contain both naturally occurring compounds and those emitted as a result of human activities. Fossil fuel and biomass burning have increased aerosols containing sulphur compounds, organic compounds, and black carbon (soot). Human activities such as mining and industrial processes have also increased dust in the atmosphere. Natural aerosols include sea salt aerosols, biogenic emissions from the land and oceans, and sulphate and dust aerosols produced by volcanic eruptions (IPCC, 2007).

Halocarbon gas concentrations have increased due to human activities; however, natural processes also contribute small amounts. Principal halocarbons include the chlorofluorocarbons which were used extensively as refrigeration agents and in other industrial processes causing stratospheric ozone depletion (IPCC, 2007).

The rise in concentration of the aforementioned man-made gases increases the atmospheric radiative force and temperatures leading to an increase in the warming of the earth's surface. The accumulation of carbon dioxide in the atmosphere over the past century is expected to cause warming of the earth. The increase in carbon dioxide is due to the fact that more carbon is released into the atmosphere than is removed (Prowse,2010). The transfer of the carbon to the atmosphere leads to a physical change in the earth's ability to capture the energy of sunlight and hold it as heat. Carbon dioxide and other greenhouse gases act like a blanket of insulation that impedes the radiation of heat from the surface of the earth into space. Consequently, temperatures rise at the earth's surface. This information show that the more carbon dioxide and other trace greenhouse gases are released, the more effective the blanket becomes. However, it should also be understood that the effect of these greenhouses gases has been exacerbated by other human activities such as deforestation. The effects of deforestation in relationship to emissions and global warming will be tackled next.

2.2.2.3.6. Deforestation

Changes in land use also affect the amount of carbon held in vegetation and soil, either by releasing carbon dioxide or removing it from the atmosphere. The greatest fluxes of carbon result from the conversion of forests to open lands (Houghton and Goodale, 2004). Practices such as removing trees by burning releases carbon dioxide into the atmosphere and prevents forests from sequestering carbon in the future. The pastures or croplands that replace the forest lack the forest canopy and tend to be warmer (Bast, 2010). Deforestation also reduces carbon dioxide uptake by plants and has a significant effect on the climate. It is one of the contributors to modern anthropogenic climate change and is estimated to directly cause about 20% of the world's greenhouse gas emissions and indirectly by reducing carbon dioxide uptake absorption by trees. It is estimated that 1.5 billion tons of carbon are released every year by tropical deforestation (Science Heathen, Geology & Climate, Plants, 2012). Given the aforementioned description and effects of greenhouse gases, the subsection that follows will provide a contrast between natural and human causes of climate change.

2.2.4.Natural versus Human Causes of Climate Change

Natural variability alone cannot explain the current overwhelming climate change trends. The average global temperatures have risen by about 1.4°F (0.8°C) since 1880. The nine warmest years in the 132-year record have all occurred since 2000, with 2010 and 2015 ranking as the hottest years on record (NASA ,2016). There is strong evidence that the warming of the earth over the last decades has been caused largely by human activity (Cook,Nuccitelli,Green,Richardson,Winkler,Painting, Way,Jacobs & Skuce,2013.).

A study carried out by Tett,Jones,,Stott,Hill,,Mitchell,Allen,Ingram,Johnson,Jones,A. & Roberts,2000) with the use of optimal detection methodology and climate model simulations estimated that natural factors have had a slight net cooling effect; hence, human factors have caused more of the observed global warming. Some argue that the analysis that human activities are causing climate change is based on climate models that are too simplistic, as the models exclude some natural variability that affects climate change, leading to overestimated anthropogenic forces (Scafetta, 2010). Computer models on climate change that included both natural forces and human influences have shown that the latter has caused an increase in global warming trends observed in recent decades (Climate Communication, 2011; Cook, *et al*; 2013). Huber and Knutti (2012) studied how both natural and anthropogenic factors influence variability in climate change. Their study revealed that since the mid-20th century, human activities (greenhouse gas emissions) have contributed about 0.6 to 1.1°C, with the statistically significant value being 0.85°C. Fifty per cent of this value was estimated to have been offset by the cooling effect from the natural variability of the earth. Their study further elaborated that change in natural forces could not account for the current global warming trends and it was extremely unlikely that natural variability would have contributed to more than 26% in the last five decades (Huber and Knutti, 2012).

It has been confirmed that human activity was responsible for more than 100% of the global surface warming since 1950, while natural factors somehow offset the trend with a slight cooling influence (IPCC, 2013). The panel further indicated that about 96 to 97% of climate scientists' pieces of research agree that humans' activities are the main cause of global warming (IPCC, 2013). Schmidt (2009), a scientist from NASA, conducted a study on the probability distribution of the warming caused by humans since 1950. The study showed that the probability of human contribution towards global warming was more than 50% (Schmidt, 2009).

The foregoing views suggest that both natural and human factors contribute to climate change, but human activities are the main causes of contemporary global warming and climate change. There has been a significant contribution of human fingerprints on carbon overload over the past century. Therefore, action should be taken to reduce emissions of these gases to counter the effects of climate change and weather. The direct and indirect effects of climate change are complex. Changes in the temperature and various forms of precipitation are major weather indicators of climate change. The next subsection will provide a review on how climate change influences these weather-related events.

2.2.5.Effects of Climate Change on Weather Patterns

Climate change is predicted to increase the frequency of high-intensity storms (Mendelsohn, Emanuel, Chonabayashi & Bakkensen, 2012). The increase in energy and heat in the atmosphere facilitates the formation of more extreme weather events. Climate change is already contributing to the occurrence of weather disasters or events (Botzen and Van Den Bergh, 2009). Trends in the increase in the frequency, intensity, and duration of some types of extreme weather events have been observed in recent years (Wuebbles, Kunkel, Wehner & Zobel, 2014).

There is increasing consensus that the global climate is getting warmer and weather patterns are changing. This is supported by increasing temperatures, storms, droughts, floods, rising sea levels, and the melting of ice and snow in various regions (Jungqvist, Oni, Teutschbein.& Futter, 2014). Recent climatic models have shown that extreme weather events associated with temperature, precipitation and sea level rise have intensified since the 1960s. The extreme weather events include heat waves or spells, very high temperatures, torrential rainfall events, flooding, and droughts depending on regions (IPCC, 2013).

Over the past few decades, meteorologists have reported a widespread rise in temperatures across the globe. This phenomenon has been termed global warming (Gao, Fu, Drake, Liu & Lamarque, 2012). An analysis of some of the extreme events that occurred worldwide in 2013 found that the probability of at least 8 of the total 16 major disasters, including floods, droughts, storms, and record high temperatures, was increased as a result of climate change (Battison, 2015). These extreme weather events have been linked to climate change and predicted to become common as the climate heats up or changes. Climate change is predicted to increase both precipitation and the sea level rise in certain areas, resulting in higher damage potential (Botzen,Aerts & Van Den Bergh; 2009). This study will focus on temperature, precipitation, and wind as major weather variables that are affected by climate change. Therefore, an overview of these climate change indicators will be outlined next.

2.2.5.1. Temperature

World trends show that the earth's temperatures are estimated to have increased by 1.0°C in past decades (Pollack, Huang & Shen, 1998). Increasing global average temperatures and warming rates have been observed over the past 30 years. Atmospheric temperatures are estimated to be 0.75°C warmer than at the beginning of the century (IPCC, 2007. An independent review of global weather data by scientists estimated that 2015 was the warmest year recorded since 1880 (NASA, 2016).Climate change is anticipated to continue to increase overall temperatures (Voorhees, Fann, Fulcher, Dolwick, Hubbell, Bierwagen & Morefield; 2011). Climate change models crafted by scientists who are part of IPCC, taking 1990 as the baseline, projected the following key climate change impacts that follow by 2100.Average global temperature is predicted to rise by 1.4 to 5.8°C, regional average annual precipitation to increase and decrease by 5 to 20%, sea levels to rise by 0.09 to 0.88 mm, and extreme events such as droughts and severe storms are also forecasted to increase (Cook, *et al*; 2013, IPCC, 2001).

As the earth's climate gets warm, heat waves are expected to become more frequent, longer, and more intense. This assertion can be seen in action. As an example, in 2003 Europe experienced its hottest summer in at least 500 years, with temperatures more than 2°C warmer than the average. In the United Kingdom, temperatures reached a record-breaking 38°C. All this attests to the impact of climate change on surface temperatures. It is also anticipated that without climate change mitigation action, temperatures could increase by a further 6°C by the end of the century (Association of British Insurers, 2005).

2.2.5.2. Precipitation

Climate change has altered not only the overall magnitude of rainfall but also its seasonal distribution and variability worldwide (Feng, 2013). It is increasing the rate of the earth's hydrological cycle; hence, extreme weather events such as more intense and frequent periods of heavy precipitation and flooding are occurring (Shukla, 2013). Total annual precipitation has increased worldwide since 1901, and occurrences of abnormally high annual precipitation have also increased. Shifting weather patterns have also caused certain parts of the world to experience less precipitation than usual.Future changes in flood risks are expected to be driven by changes in climate. Climate models project increases in the frequency and intensity of heavy rainfall, which would contribute to increases in precipitation generating flooding (Kundzewicz, Kanae, Seneviratne, Handmer, Nicholls, Peduzzi, Mechler, Bouwer, Arnell, Mach & Muir-Wood, 2014).

There is a direct relationship between global warming and precipitation. As the climate warms up, rising temperatures cause an increase in evaporation in the atmosphere. High levels of water vapour in the atmosphere create more favourable conditions for heavier precipitation in the form of intense rain storms and floods .Increased heating also leads to greater evaporation, which, in turn, causes earth's surface to dry up, thereby increasing the intensity and duration of droughts (Trenberth, 2011).

Extreme weather events, as evidence of a warming world, are already occurring and are expected to continue. On average, small changes in some key climate variables can lead to large changes in weather damages (Climate Communication, 2011). More so, extreme weather events such as droughts and floods are becoming more destructive and frequently leading to communities, cities, and nations suffering damages and agricultural output being disrupted as well (Radhouane, 2013).

2.2.5.3. Windstorms

Changes in wind speeds as a result of climate change are predicted to increase. Evidence suggests that long-term changes in the atmospheric circulation of winds will likely continue (Feng, 2013; Voorhees, *et al*; 2011). Climate change is projected to have a considerable impact on global wind speeds. Weather patterns are shifting every year, and the variability could be an inherent effect of climate change. In some parts of the world wind speeds are increasing while decreasing in other parts (Eichelberger,McCaa, Nijssen, & Wood, 2008). In Southern Africa, various studies have shown that the likelihood of changes in circulatory systems was increasing. The probability of extreme wind speeds has also been evident in South Africa, a 10% increase in wind speed at 10m above ground level is predicted by 2100 (Herbst and Lalk, 2015). Winds can cause significant damage to properties (Salazar, 2015). Wind storms or extreme winds can lead to extensive infrastructure damages and trees being uprooted and falling on property (Becker , Nissen & Ulbrich, 2015).

The three aforementioned weather variables are interlinked. According to Diamond (2011), an increase in temperatures modifies jet streams, altering global air circulation and local wind flows, which could increase or decrease average wind speeds in different locations. As a result, some areas might experience more violent weather conditions and turbulent wind speeds (Diamond, 2011). In addition to this, rising temperatures cause an increase in evaporation in the atmosphere, which creates more favourable conditions for heavier precipitation in the form of intense rain storms and flooding .These violent weather events are projected to increase as climate changes. This will consequently lead to rising weather-related damages which will have considerable effects on societies and businesses, and the insurance sector in particular. In view of that, an understanding of the effects of climate change on the insurance business is important for the sector in order to guarantee adequate pricing of insurance premiums, claim payouts, and risk management practices.

2.3. Effects of Weather Damages on Short-term Insurance Losses

Before discussing the effects of weather damages on short-term insurance losses, it will be prudent to discuss the insurance sector and its categories.

2.3.1.Insurance and its Categories

Insurance is a risk management tool and a means to provide protection against the possibility of financial loss. It involves the transfer of risk in a two-party contract. The entity that provides insurance is known as the insurer, and the person or entity that purchases insurance is known as the insured or policyholder. Insurance is a contract in which the insurance firm promises to provide compensation for a specified loss in exchange for an agreed premium or payment after an underwriting assessment. Underwriting is the process of assessing the risk (subject or item to be insured) in order to accept or decline it. If the risk is found to be desirable, it is then accepted, and a premium that commensurates with the risk level will be charged. For insurers to underwrite a risk, the following insurability measures should be satisfied: The risk must occur fortuitously – beyond control – and there should be an insurable interest and ability to quantify the loss (Zurich, 2009).

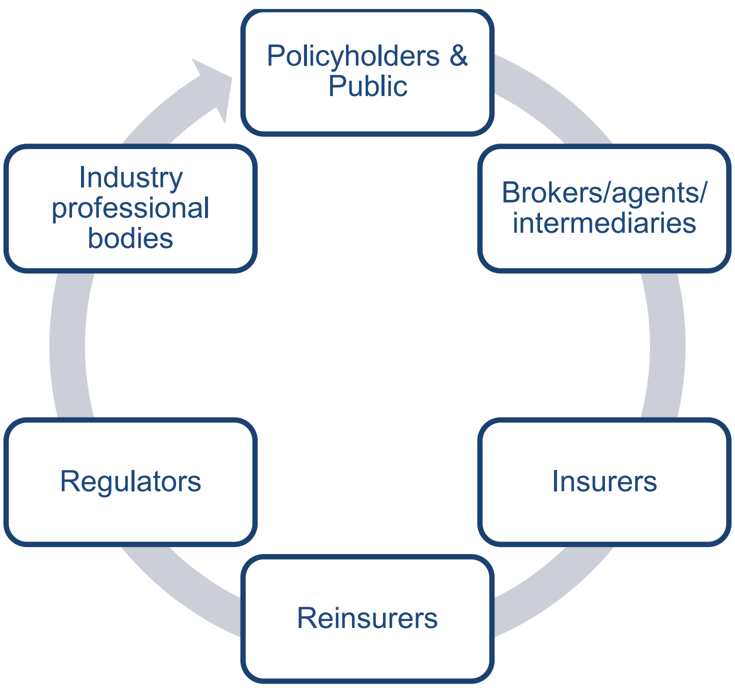
Insurance aims to provide indemnification or financial security against a possible eventuality. Insurance is a risk transfer tool that ensures full or partial compensation for loss or damages which occur as a result of circumstances that the insured cannot control. The insurance concept or business model succeeds through pooling or spreading of risks. A group of customers who purchase insurance for protection against certain perils contribute their premiums into an insurance "bucket". As a result of large numbers of policyholders, insurers utilise statistical analyses to predict future losses. Insurers spread the cost of losses over those policyholders exposed to the probability of a loss. This principle is based on the notion that not all policyholders will incur losses at the same time or at all. This allows insurance businesses to operate profitably and settle claims (Valsamakis, *et al*; 2010). Besides the pooling effect, insurers also use reinsurance mechanisms to manage their exposure to large and catastrophic losses (Zurich, 2009).

There are two categories of insurance, namely, long and short-term insurance. Long-term insurance focuses on the person's life, death, and living benefits, whereas short-term insurance deals with protecting one's belongings or possessions, such as homes, vehicles, and properties. Long-term insurance is taken to protect or minimise the effects of life-changing events or circumstances such as retirement, death, investments, illness, funeral, and disability. In long-term policies, one pays a premium until they die or the policy matures or for a specified time, usually more than a year .The Long-term Insurance Act, No. 52 of 1998 defines long term as contracts that comprise disability policies, funds (investments), life or funeral policies, or a combination of any of those policies. Short-term insurance policy refers to engineering, guarantee, liability, miscellaneous, motor, accident, health, property or transportation, or a contract comprising a combination of any of those policies which are renewed or varied (South Africa, 1998). Short-term insurance covers belongings or assets, and the contracts are normally for a year. The policies cover damages or loss to vehicle, property, household, medical, personal liability, and business insurance.

2.3.2.Structure of the Short-term Insurance Industry

It is also important to understand how the insurance industry interacts and engages with its stakeholders. On that account, a brief outline of the structure of the industry will be provided. Figure 2.1 shows how the short-term insurance industry operates. A brief summary of the role played by each stakeholder is also outlined next.

Figure 2.1: Structure of the Insurance Industry



Source: Author

2.3.2.1. Policyholders

These are the individuals, businesses, or public authorities that purchase insurance and pay a premium so that they can benefit from protection and compensation in the event of a loss.

2.3.2.2. Brokers

They are also known as agents or intermediaries that facilitate the distribution of insurance products or solutions. They link insurers and customers; render advice; provide risk management information; and negotiate insurance sales, price, placement terms and conditions on behalf of customers. They also assist policyholders at claims stage with the interpretation of contract agreements, settlement negotiation, and claim processing. Brokers normally receive remuneration for their services from insurers on a commission basis. Some of the leading insurance brokers in South Africa are Aon, Marsh, and Alexander Forbes.

2.3.2.3. Insurers

They are also known as underwriters. These are companies that carry the risk and are responsible for underwriting the risk as well and claims settlement. They assess the risk profile and make a decision to accept or decline it. If they accept, they charge a premium that commensurates with the risk and provide terms and conditions of the insurance contract. In the event of a loss or claim, the insurers are responsible for settlement. Some of the leading insurance companies in South Africa are Santam, Mutual & Federal, Hollard, Outsurance, Telesure, and Discovery Insure.

2.3.2.4. Reinsurers

Reinsurers are insurance companies that offer insurance protection to insurers. They underwrite risks that are too big or outside the financial capacity of primary insurers. Reinsurance allows insurers to take on risks that they would not have been able to insure or fund. Insurers, depending on their risk exposure and capacity, buy insurance policies from reinsurers and pay a premium through a process known as cession, to limit exposure. Reinsurers are important especially in this era where the climate is envisioned to increase weather-related catastrophes. Reinsurance supports the insurance industry in spreading the effects of weather disasters. It provides protection to insurers in the event of losses or disasters. When disasters occur, insurers might be faced with unprecedented levels of claims that exert pressure on their capital reserves. Reinsurance helps insurers to diversify their funds and risks, and provides another layer of safety net so that they can remain solvent (Aon Insurance Brokers, 2016). Leading global reinsurance companies are Munich Re and Swiss Re.

2.3.2.5. Regulators

There is an array of pieces of legislation and laws that short-term insurance businesses and insurance organisations should comply with to operate in the Republic of South Africa. Regulators are responsible for registration and licensing of insurance businesses. They also have a mandate to supervise, enforce, and monitor insurance businesses to ensure compliance with all relevant and applicable Acts of parliaments, industry laws, and regulations such as the Short-term Insurance Act and the Financial Advisory and Intermediary Service Act (FAIS). The FSB is mandated to enforce and supervise compliance with legislation in the insurance sector.

2.3.2.6. Industry and Professional Bodies

These are recognised legal and reputable entities that represent and promote the short-term insurance industry's interests. They assist in skills development, information dissemination, and monitoring professional practices or conduct of members. They aim to improve cooperation and engagement amongst stakeholders to enhance fair and ethical treatment of customers. Professional bodies are governed by codes of conduct and to ensure members adhere to best practice industry standards. Examples of bodies in South Africa include the South African Insurance Association, The Insurance Institute of South Africa, Financial Intermediary Association, and many others.

The foregoing structure facilitates economies and communities to access financial security for their assets and property. Short-term insurance is taken out by both individuals and businesses to protect their assets and belongings. To understand the ignominy of climate change impact on the insurance industry, it is also important to first analyse its importance in business and economic activities. Insurance serves consumers and businesses as a safety net against risks (Ceres, 2014). Insurance markets work by pooling risks across a large and diverse population. Individuals or businesses protect themselves against uncertain loss by paying an annual premium towards the pool’s expected losses. The insurer holds premiums, investment income, and supplementary capital in a fund to compensate those that experience losses (Association of British Insurers, 2005). The insurance industry assists with recovery in the aftermath of a disaster, as it implements risk mitigation procedures to minimise the impact to society and businesses (Kennedy, 2010).

2.3.3.Evidence of Weather Damages on Insurance Policies

Weather disasters affect both long-term and short-term insurance categories. Baez, Fuente and Santos (2010) outlined that disasters can cause loss of life, disruptions, and destruction of property. Long-term and short-term insurers across the globe have been dealing with the effects of climate change for years (Nevius and Horkovich, 2015). When weather disasters strike and cause damages, long- and short-term premium-paying policyholders cascade costs to the insurance markets (Von Dahlen and Von Peter, 2012). Both insurance categories are crucial in dealing with the effects of climate change, but this study will focus on the short-term insurance industry. This is because the short-term insurance industry is highly vulnerable to the effects of climate change (Mills, 2003). The rising weather losses or costs directly affect the short-term insurance industry. Further to this extreme weather events have been a leading driver of property and casualty insurance claims (McHale and Leurig, 2012).

Climate change brought a new set of economic and financial risks emanating from changing weather trends (Gurenko, 2007). About 300 different global natural disasters were recorded in 2015, compared to the 15-year average of 269 events (Aon Insurance

Brokers, 2016c). Since insurance services provide peace of mind and financial security to policyholders, the industry is vulnerable to weather events. The consequences of climate change and increase in losses are negative on insurance affordability, availability, and industry growth (Mills, 2005).

The driving forces behind increasing insured weather-related losses are complex, but there are indications that climate change is becoming one of the main contributing risk factor (Prudential Regulation Authority, 2015). The projected rise in weather-related damages will have considerable effects on societies and the insurance sector in particular. Climate change has become a major consideration when insurers provide coverage for weather insurance (Association of British Insurers, 2016). Adverse weather events damage property, economies, and ecosystems, which can translate into insurance losses (Canadian Climate Forum, 2014).

Some insurers are already facing some risks of increased insurance payouts towards flood, storm, drought and fire damages under current arrangements. Weather events affect built infrastructure and property (Chappin and Van der Lei, 2014). The probability of fire damage to buildings or property is higher in dry periods, which can increase insurance losses (Botzen, *et al*; 2009). Climate change has short- and long-term threats to the insurance industry. It can affect underwriting and risk management models, claims management, and business strategies. Increases in weather hazards can also lead to a rise in correlated claims, threatening the availability and affordability of weather insurance (Herweijer,Ranger & Ward 2009).

The insurance industry bears the greatest portion of weather-related risks, since its main business is of providing cover for acts of God, sudden, unforeseen, and accidental losses or damages (Mills, 2007a). To put this into perspective, it is observed that since the 1980s, there has been an upward trend in weather-related disaster losses. During the 1980 to 2012 period, the estimated total reported losses due to disasters amounted to US$3.8 trillion. More so, weather-related disasters accounted for 74% (US$2.6 trillion) of total reported losses. In Thailand,2011 floods resulted in losses of approximately US$45 billion, equivalent to 13% of the country's gross domestic product (GDP) (World Bank, 2013). Therefore conclusively it can be argued that climate change challenges the sustainability of insurance because increasing variability of hazards could lead to more unpredictable claims patterns (Lamond and Penning-Rowsell, 2014).

Insurance has been experiencing climatic losses for many years (Stahel, 2009). This has led to some major insurance companies adapting their business model to the realities of climate change. Some insurers have begun responding to climate change and are improving efforts to build climatic risk resilience by providing risk management expertise and loss reduction incentives (Mills, 2009). This is evident as some insurers and brokers are coming up with possible solutions to minimise the impact of climate change. Table 2.1 outlines some of the initiatives that have been introduced by some insurers.

Table 2.1: Insurance Industry Response to Climate Change

Company	**Initiative**	**What Is Involved**	**Countries Operated**
ACE	ACE Green	Building restoration insurance products. Deals with additional costs incurred by property owners who desire to rebuild a more environmentally friendly or "greener" property after a loss	Global insurer – including South Africa
AIG	Ecopractice and Advance Energy Solutions	Encouraging environmentally/eco-friendly practices in business activities – to reduce emission, save energy and resources to achieve sustainability	Global insurer including South Africa
Allianz Insurance and Asset	Allianz Climate Solutions	Subsidiary formed to deal with insurance for renewable energy technologies and climate-related	Global Financial Services Provider

Company	Initiative	What Is Involved	Countries Operated
Management		risks	
Aon	Aon Carbon	To promote carbon reductions and manage companies' carbon footprint – Aon launched a new personal indemnity insurance to cover error on carbon estimates and reduction	Global insurance brokers including South Africa
Chubb	Green Energy Team	The team of specialist deals with green, energy efficient and renewable insurance products	Global insurer
Zurich	Climate Initiative	Launched to facilitate product development, carbon footprint and climate change-related research or dialogue	Global insurer including South Africa

Source: Mills (2009)

Climate change has become an important business risk and should be brought into the mainstream of business operations. Leading insurers around the world have come together to establish teams and partnerships with the goal of dealing with climate risks. There is a worldwide increase in collaborations between insurers, government agencies, and academic institutions in fighting climate change. For example, Earth Institute at Columbia University and Swiss Re are working together in implementing satellite-based remote weather-sensing technologies to support microinsurance in Africa. Munich Re and the London School of Economics also partnered to understand the economics of climate change. Zurich Canada funded pieces of research conducted by Simon Fraser University on adaptation to climate change. Additionally, Munich Re and other insurance companies such as Tokio Marine Holdings have been contributing to the work done by the IPCC. Global insurers have also come together to form networking groups such as ClimateWise and joined platforms such as the United Nations Environmental Programme (UNEP) Finance that seeks to reduce climate-related risks and formulate strategies to improve disaster resilience and adaptation (Mills, 2009).

Leading South African industry players such as Santam and Aon joined ClimateWise and UNEP Finance. Locally, Santam has also collaborated with the Council for Scientific and Industrial Research (CSIR), University of Cape Town (UCT), and the Worldwide Wildlife Fund (WWF) since 2010 to understand climate risks and how they affect society. Santam also partnered with the South African Insurance Association, Department of Trade and Industry, Department of Energy, and Eskom to support the Green Geyser Replacement Programme. The programme is designed to replace faulty electric geysers with energy-efficient alternatives including heat pumps or solar water heaters (Santam, 2012). Santam is also involved in the Business Adopt-a-Municipality (BAAM) initiative in which it partnered with a number of communities and municipalities in South Africa to enhance disaster risk management and community resilience. The insurance sector should continue to bring climate change into the mainstream of its business operations and be equipped to manage the new risks that come from climate change in order to help customers manage to these risks (Association of British Insurers, 2005).

Current evidence suggests that global insurance payouts from weather-related losses are increasing. The number of registered weather-related losses has tripled since the 1980s. Inflation-adjusted insurance losses from weather events have increased from an annual average of about US$10 billion in the 1980s to about US$50 billion over the last decade. Over and above that, the magnitude of payouts made to policyholders by insurers is increasing and affecting insurers' balance sheets, signaling potential correlation. This indicates how weather-related events are becoming increasingly correlated to insurer claim payouts, thus challenging insurance business models and assumptions (Prudential Regulation Authority, 2015).

Conclusively, insurance continues to play a vital role in supporting economic growth and innovation by underwriting new and changing risks. The rising weather-related losses pose a significant challenge to the industry, with extreme weather events resulting in an unprecedented increase in insurance claims for vehicles, commercial and household properties, crop or agriculture. This has prompted major insurance players to consider climate change as a material and systematic business risk. It is also observed that the increasing severity and frequency of weather losses show the impacts of climate change. Further, the insurance industry is becoming increasingly active in understanding climate change. For example, organisations such as ClimateWise have been established to understand the effects of climate change (Prudential Regulation Authority, 2015). Rising weather losses and costs have considerable negative effects on solvency margins and capital requirements; hence, some insurers have become advocates in fighting emissions and climate change (Tucker,1997). Although weather-related losses are linked to climate change, there are some socio-economic factors that can worsen the extent and magnitude of losses suffered.

2.3.4.Other Factors That Influence Short-term Insurance Weather Losses

Socio-economic factors such as economic growth, urbanisation, increasing wealth accumulation, and insurance penetration also contribute and exacerbate weather-related losses (Houghton, 2011; Botzen, 2009; Mills, 2005). Some of these factors will be reviewed next.

2.3.4.1. Economic and Insurance Industry Growth

Economic growth is measured by GDP. GDP is the total or aggregated value of goods and services produced in a country during a specified year, and it is used to show economic progress (Lipsey and Chrystal, 1999). If GDP is increasing, this indicates that the economy is performing well and the standard of living is improving. However, if GDP is falling, it signals that the economy is not doing well. GDP can be used to indicate the wealth of a nation (Knight, 2014).

On a global scale, economic growth and urbanisation have become real drivers of the increase in exposure of assets to weather losses (Hanson, Nicholls, Ranger, Hallegatte, Corfee-Morlot, Herweijer & Chateau, 2011). The main driver of rising greenhouse gas emissions can be linked to wealth-related consumption and exposure (Hoeppe, 2016; Knight, 2014). Therefore, increasing asset accumulation, consumption, and exposure are important drivers of weather risk and losses (Ward and Ranger, 2010). This is because changes in economic growth, wealth, and asset accumulation changes vulnerability and influence loss trends (Visser, Petersen & Ligtvoet, 2014). On the contrary, an increase in wealth and economic growth could increase resilience and adaptation (Liu, 2012). However, an increase in wealth per capita generally means that individuals have more possessions. As the nation acquires more personal wealth, losses will continue to increase (Pielke,Gratz,Landsea Collins ,Saunders & Musulin,2005). Therefore, economic growth and accumulation of wealth remain key drivers of future losses (Barthel and Neumayer, 2012). This is so because increase in economic growth and wealth will lead to an increase in insurance demand or penetrations, hence the increase in exposure will consequently number to weather-related losses or claims.

2.3.4.2. Changes in Insurance Penetration or Demand

Insurance penetration shows insurance consumption and market size. Insurance penetration indicates how much people spend on insurance; thus, total gross written premiums can be used to measure insurance penetration, demand, markets growth, and development (Petkovski and Jordan, 2014). According to Petkovski and Jordan (2014), insurance penetration can be measured by changes in aggregate written premiums across different lines of insurance. Globally, economic growth and development influence the increase in insurance demand and growth in insurance markets. This is because improving economic conditions, education, and urbanisation change insurance penetration trends (Cristeaa, Marcu & Carstina, 2014). According to, (Sinha, Nizamuddin & Alam, 2012), insurance penetration is positively correlated with GDP growth rates, and the linear relationship show that insurance increases as the GDP increases. Insurance penetration is estimated to be 9% of GDP in developed economies and 5% of GDP in less-developed economies (Mills, 2005). The demand for insurance is driven by wealth and stock of assets; economies with a high demand for insurance tend to spend more on insurance, since they have more assets to protect (Petkovski and Jordan, 2014). The rise in insurance penetration influences weather loss patterns and claims received by insurers (Bouwer, 2011). Von Dahlen and Von Peter (2012) agree that volatility and vulnerability to weather damage also depend on insurance penetration and demand. There is likely to be greater insured weather losses where insurance penetration is high.

An increase in economic growth and insurance penetration is likely to increase weather-related losses and claim payouts (Mills, 2005). Because of that, this study recognises that there are some non-climatic factors that influence weather-related claims. Additionally, non-climatic factors such as insurance penetration will also be considered in this research model for two main reasons. First, to ensure that research is modelled on a more objective scenario that mirrors the ideal insurance environment, and secondly, to also avoid problems of multicollinearity and spurious correlations. The model will use insurance penetration (gross written premium) as the control variable to explain insurance growth and consequently weather-related claims.

As the accumulation of assets and insurance penetration increase, losses from weather events are likely to increase than before. Gross written premium will be used as a proxy for insurance penetration, since it reflects wealth covered by insurers or stock at risk of destruction from extreme weather events. However, it should be noted that some scholars indicate that global weather-related losses in past decades have been growing at a faster rate than socio-economic factors such as insurance penetration and economic growth (Mills, 2005). This view shows that climatic factors play a more pivotal role in influencing weather-related losses.

2.4. Global Trends of the Effects of Weather Events on the Insurance Industry

Leading international insurance players became concerned about the effects of the changing climate and potential rise in weather losses since the 1970s. As a result ,Some insurers are already spearheading activities such as climate change awareness, research, collaborations with science academics, policymakers, and communities to find ways to mitigate effects of weather risks (Prudential Regulation Authority, 2015).

Losses related to weather events have been on the rise (Changnon, Pielke Jr, Changnon, Sylves & Pulwarty, 2000). Global financial losses from weather conditions have been escalating since 1960 and placing a significant financial burden on the insurance industry (Association of British Insurers, 2005; Munro, 2010). Insured losses from weather-related events rose from 0.018% of global GDP from 1974 to 1983 to 0.077% of global GDP from 2004 to 2013 (King , 2014). The total reported losses due to disasters were estimated to be US$3.8 trillion from 1980 to 2012, and weather-related disasters accounted for 74% of total reported losses (Gitay, 2013). Globally, economic losses due to natural disasters have increased sevenfold in the last 40 years, while insured losses have increased fourteenfold. Climate change is indeed affecting the global insurance industry. Global trends show that weather disasters can be costly as shown in Table 2.2.

The data in Table 2.2 shows various countries that have been exposed to different weather disasters such as hurricanes, windstorms, flooding, drought, and cyclones. The statistics show that the severity and cost impact suffered by insurers as a result of weather-related damages has been significant. These weather events cost insurers in different continents billions of dollars from 1992 to 2012.

Table 2.2 also provides detailed information and distribution of worldwide economic and insured weather-related losses from 1980 to 2014. The table shows that world economic and insured weather-related losses have generally been increasing. The economic and insured costs of weather-related events from 1980 to 2014 after being adjusted to the effects of inflation have been estimated to be US$3.3 trillion and US$960 billion respectively. In light of these costs of weather damages, the insurance industry and society should be concerned and understand the factors that are influencing such an upward trend in weather losses.

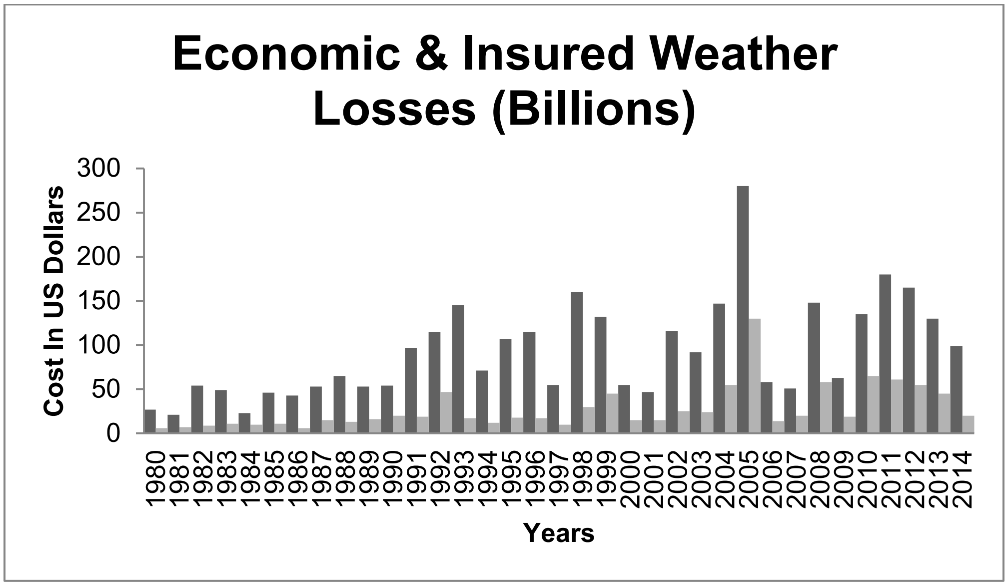
Table 2.2: Weather-insured Loss Trends For Selected Countries

Country	Weather Events	Year	Insured costs in US$
Florida (US)	Hurricane Andrew	1992	15.5 to 22 billion
Europe	Windstorms	1999	11 billion
Europe	Heavy rains/flooding	2002	4 billion
United States and neighbouring countries	Hurricanes	2004	30 billion
Japan	Tropical cyclones	2004	7 billion
US Federal Crop Insurance Programme	Drought/high temperatures	2012	17.3 billion
Thailand	Flooding	2011	45 billion
United Kingdom	Storm/Floods	1998-2003	6 billion (Pounds)

Sources: Gitay (2013); Munro (2010); Association of British Insurers (2005); Dlugolecki (2004)

Trends in Figure 2.2 demonstrate that world insurers are becoming increasingly vulnerable to weather losses. Climate change is increasing the likelihood of extreme weather events that can lead to large losses and capital depletion of insurers (Standard & Poor, 2014). Balance sheets and financial assets reserved by insurers to meet claims may be negatively affected due to increasing weather-related costs (Maynard, 2008). Therefore, insurers will need access to more capital to smooth out losses from very severe weather (Association of British Insurers, 2005). This will reduce the industry's ability to help clients, manage risk, and respond to new business opportunities (Environmental and Energy Study Institute, 2012). It will consequently affect the long-run provision of insurance coverage against weather damages. On the other hand, the above-mentioned cost trends show the positive contribution played by efficient financial and insurance markets, in providing prompt financial relief, facilitating recovery and reconstruction in the aftermath of a disaster

Figure 2.2: Estimated Worldwide Global Losses from 1980 to 2014



Source: Munich Re (2015)

2.5. Positive Effects of Climate Change on Short-term Insurance

Insurance services support wider economic growth and efficient allocation of capital. Insurance increases the resilience and adaptation of households and entrepreneurship. It protects companies and individuals from perils and unexpected shocks they could not have otherwise shouldered. Weather-related risks directly damage property and indirectly disrupt business operations and supply chains. Insurers enable market-based transfer and pooling of risks that would be difficult for individuals or businesses to bear (Prudential Regulation Authority, 2015).

The consequences of climate change might not be entirely negative. Weather-related loss trends support the growing importance of weather insurance. Sufficient adaptation and risk management strategies from insurance companies will be required to handle the increasing risks (Botzen, *et al*; 2009). Therefore, climate change presents a stronger case for insurance business and risk management solutions (Hawker, 2007). Insurers might benefit and increase their revenues through developing new products and services that respond to climate change risks. New business opportunities may also come from incentivising, creating policyholder awareness, and encouraging the use of green products to reduce climate change (Mills, 2009). Insurers might also benefit from the increase in demand for climate risk insurance and advisory services as people seek to adapt and mitigate their potential weather risks (Mills, 2005; Herweijer, *et al*; 2009). The insurance sector can benefit from proactively designing products that respond to sustainability needs of their customers. This can lead to new innovations to ensure availability and affordability of climate risk insurance to previously uninsurable market segments (KPMG, 2012). Thus, climate change might lead to the growth of existing insurance markets, development of new financial markets, risk-related products and services to improve adaptation and minimise vulnerability.

Climate change might consequently create an insurance boom in the future because more people will need insurance coverage against weather-related risks. This can foster the development of new profitable insurance markets and products for climate risk mitigation (Haufler, 2009). Proactive insurers could seize climate change opportunities through product innovation and build brands that resonate with sustainability (Deloitte, 2015). Further to this, the flexible nature of short-term insurance contracts can allow insurers to quickly adjust premiums to accommodate changes in loss trends, collect adequate premiums and to avoid operational losses (Botzen, 2009; Haufler, 2009). On the contrary, the unpredictability of weather risks might impede development and growth of insurance markets (Kunreuther and Michel-Kerjan, 2007). This is because rising weather claims can potentially reduce the insurance industry's pricing and pooling capacity, thus leading to losses (Hawker, 2007). However, if insurers timely predict and take into account the possible effects of climate damages in their business models, insurance would remain a good climate risk management tool, as the required premiums would be relatively stable and known prior to the loss (Crichton, 2002).

2.6. Climate Change Controversy in the Insurance Industry

Climate change has however stimulated controversies and debate amongst short-term insurance players (Mills, *et al*; 2001). In general, weather-related costs are beginning to put the industry in a difficult situation. Some have begun to seriously consider climatic risk and are already taking action to improve and support climate change risk mitigation. These insurers are facilitating adaptation through partnerships with policymakers (Crichton, 2002). Others have not revealed their opinions and still do not consider climate change to be a material risk. Cautious insurers have chosen to pursue some research to enhance disaster preparedness, while others have chosen to wait and see (Mills, *et al*; 2001; Mills, 2003). While it appears to some that climate change is definitely happening in the long term, other insurers maintain that it is still difficult to link or attribute current extreme weather events to climate change. However, there is consensus in the industry that insurers are already paying out billions of rands towards weather related claims as a result of adverse weather conditions (Hollard, 2014).

Weather-related risks affect all insurance classes such as property, agriculture, cars, and aviation. The industry is strategically on the front line when it comes to financing the cost recovery and clean-up efforts in the aftermath of weather disasters (Deloitte, 2015). The magnitude of weather-related losses has raised fears in insurance markets, with some insurers already retreating from near-shore risks and promoting extensive risk management approach, while others have begun prompting policy discussion amongst stakeholders (Nevius and Horkovich, 2015).

Some insurers agree that global warming and climate change are already putting a strain on their insurance business, whereas others are still sceptical. Sceptical insurance players remain largely unprepared for weather disasters and might fail to plan for the emerging weather claims and are likely to face difficulties in maintaining reserves and profitability. Some of these insurers who have not taken climate change seriously have begun retreating away from climate risks by limiting or excluding coverage (Mills, 2005). Furthermore, the industry's weather-related loss data is poorly recorded and analysed because sceptics are still not willing to share their loss experience (Botzen, *et al*; 2009). Proactive insurers are now leading the discourse of capitalising and supporting sustainability efforts through underwriting of green insurance products and undertaking research to understand the problem (Deloitte, 2015). Some scholars carry different views and argue that the increase in weather-related claims is due to climate change, while others have attributed the increase in losses to increasing exposure due to higher economic growth, insurance penetration, increase in wealth accumulation, vulnerable assets, and population growth (Botzen, *et al*; 2009).

Despite varying views on climate change and insurance losses, Bouwer (2011) indicated that climate change damages are real as evidenced by economic and insured consequences of weather disasters that have been recorded over the past decades. Further to this, the recorded data shows that weather-related losses such as storms, cyclones, floods, fires, and hailstorms have increased around the globe (Bouwer, 2011). These weather disasters or events appear to worsen as global warming increases. This has, in turn, had an impact on the global insurance industry which has recorded a significant increase in insured weather disasters. The increase in the frequency and severity of heat waves, fires, cyclones, hailstorms, and floods affect all classes of insurance. The insurance industry continues to be faced with challenges in risk pricing, capacity or reserve building to cater for increasing weather-related losses (claims) (Berz, 1999). As the weather damages and claims increase, these insurers should assist with risk adaptation; the best strategy for insurers to survive would be to incorporate climate risks into their business and pricing models (Mills, 2005).

2.7. Climate Change in South Africa

As the global climate continues to change, developing countries such as South Africa are also faced with an increase in weather-related losses (Gitay, 2013). Weather changes have led to the destruction of properties and communities (Deonarain, 2014). South Africa is a signatory to the UNFCCC. It regards climate change and its effects as one of the greatest threats to sustainable development (COP17,Govender 2011). Climate change problems are expected to continue to increase in the future in South Africa. This suggests that an increase in the frequency and severity of events such as rain, floods, heat waves, droughts, bush fires, and hailstorms should be expected. Therefore, more extensive damage, economic, social, and environmental impacts from weather-related disasters are likely to be experienced (Warner, Loster, Zissener, Kreft, Linnerooth-Bayer, Bals, Höppe, Gurenko, Burton & Haas, 2009).

2.7.1.Causes of Climate Change in South Africa

South Africa is located in the subtropical zone of the southern hemisphere, and the climate is also influenced by a variety of natural factors. The country’s complex climate is influenced by various rainfall patterns, a wide range of elevations typical of Southern Africa, and by the Indian and Atlantic Oceans. The temperatures vary from over 32°C in summer and below freezing point during winter. Different ocean currents result in the east coast experiencing temperatures that are about 5°C warmer than in some parts of the western coast. The ocean currents also influence variations in rainfall from west to east. The north-west generally receives less than 200 mm of rainfall per year, whereas in the east it could be over 500 mm per year. Rainfall variability is also influenced by El Niño Southern Oscillation (ENSO) events and sea surface temperature changes of the Indian and South Atlantic Oceans. Inland areas have greater variability in temperature ranges associated with higher elevation (United Nations International Children’s Emergency Fund [UNICEF], 2011,Karmalkar,McSweeney, New. & Lizanco,2010,). ENSO often has meteorological and ecological impacts on the earth’s and sea surface temperatures, shifting rainfall, and temperature patterns (Jury, 2013). The foregoing shows that South Africa’s climate is also affected by natural factors which are beyond human control.

Although the climate is influenced by natural factors, it appears anthropogenic factors, mainly greenhouse gas emissions, are also playing a major role in influencing climate change in South Africa. At the 2011 climate change negotiations in Durban, South Africa was one of 190 countries that agreed to limit the increase in global average temperature to 1.5 or 2°C above pre-industrial levels, to avert dangerous climate change. Global anthropogenic greenhouse gas emissions must fall by at least 50% below 1990 levels before 2050 to have even a 50% probability of holding the global temperature increase to 2°C (Plambeck, 2012).

Countries are emitting greenhouse gases as a result of processes of industrialisation, but South Africa is the second-largest emitter of carbon dioxide on the African continent, and its per capita emissions are higher compared with other African countries. This is due to the predominant use of coal-based energy production methods, since it is one of the most carbon-intensive economies in the world (Ziervogel, *et al*; 2014). South Africa's greenhouse gas emissions per capita are about twice as high as other developing countries such as Cuba, Mexico, and Argentina, and per capita emission rates are similar to those of some developed countries such as Austria and Spain (Department of Environmental Affairs, 2007).

There is overdependence on the use of coal as the primary energy source, and this is resulting in relatively high per capita emissions of greenhouse gases (Department of Environmental Affairs, 2007). The vast majority of South Africa's carbon emissions (about 80%) are produced by the electricity sector, the metals industry, and the transport sector. These already high levels of gas emissions are expected to increase as the economy grows (Department of National Treasury of South Africa, 2010). The most significant sources of greenhouse gas emissions in South Africa are energy production industries, road transportation, manufacturing industries and construction, enteric fermentation, forest land use, and iron and steel (Department of Environmental Affairs, 2011). The increasing greenhouse gas emissions from these human activities affect the temperature as well as rainfall patterns. Scientific evidence shows that anthropogenic climate change is having a significant impact on the frequency and severity of weather events (Ward, Herweijer, Patmore & Muir-Wood, 2008). Climate change is already affecting South Africa in various ways, as evidenced by an increase in the risk of fires, droughts, storms, and floods that have caused death, injury, population displacement, and loss of property (Myers, 2012).

2.7.2.The Effects of Climate Change and Observed Trends for South Africa

South Africa is experiencing some climate change. It is already seen to be influencing the strength and frequency of weather activities such as storms, cyclones, floods, and droughts in South Africa. The prospect of future climate change is likely to have significant implications for certain extreme weather events in South Africa (IPCC, 2007). In the past 50 years, changes in climate patterns have been observed in South Africa. Mean annual temperatures have increased by at least 1.5 times than the observed global average of 0.65°C (Department of Environmental Affairs, 2013). South Africa was affected by drought, with December 2015 being described as the driest month in the past 15 years (Cho, 2015). Temperatures have risen significantly and are predicted to continue, with an increase of 1 to 2°C expected in coastal regions, and 3 to 4°C expected in interior regions by 2050 (Griffin, 2012; Deressa, Hassan & Poonyth, 2005; Gbetibouo and Hassan, 2005; Govender, 2011). Observed records of South Africa's climate also show that average annual temperatures are increasing and in some regions average annual precipitation has been decreasing since 1970 to 1990 (UNICEF, 2011, Karmalkar, *et al*; 2010).

Rainfall patterns are also shifting. Significant changes in rainfall variability and intensity are projected throughout the country, resulting in floods and droughts. Some provinces are expected to get drier and experience more severe droughts, while coastal storms are also likely to become more intense. Heat waves, floods, droughts, storm surges, and wildfires are examples of natural disasters that have become common in South Africa. Observed trends also show that the intensity of both rainfall events and dry spell durations is increasing (Department of Environmental Affairs, 2013). Climate change is likely to have notable effects on the frequency and intensity of future weather events in South Africa (IPCC, 2007). Thus, a change in temperature patterns, rainfall variability, and intensity should be expected throughout the country if no action is taken to combat climate change (UNICEF, 2011*).*

Climate change is real in South Africa, and the country has been experiencing some extreme weather events (Department of Environmental Affairs, 2013). As an example, Western Cape residents experienced serious flooding, and KwaZulu-Natal coastal residents suffered severe losses in 2007 from violent storms. Farmers across the country lost thousands of hectares of grazing and crops as a result of runaway fires. In the year 2000, notable incidents of heavy snow covered Kokstad, Matatiele, and Underberg, while fires destroyed more than 200,000 hectares of grazing land in the Eastern Cape and Free State. In 2001, the Western Cape experienced severe flooding, while areas such as Memel and Vrede, Chrissiesmeer, and Ermelo suffered fire damage estimated to run into millions of rands. Runaway fires caused R350 million in damages in the Dundee, Volksrust and Vryheid area. Strong winds and hail caused around R2.7 million in damages in Johannesburg. In 2002, 2003 and 2004, strong winds, fires, and extreme floods caused damages. In 2005, hail the size of a hen's eggs fell in Limpopo. Fires also ravaged the Free State, KwaZulu-Natal, Mpumalanga, and Limpopo (Momberg, 2008). These incidents show that climate change is already playing a role in changing weather patterns, and projected future climate changes should be considered.

If the current rate of burning fossil fuels and chopping down forests continues, the cost of damages due to extreme weather-related events (flooding, fire, storms, and drought) is likely to increase (COP17,Govender, 2011). According to Madzwamuse (2010), weather changes and costs are likely to have significant impacts on the South African economy (Madzwamuse, 2010). The sector of the economy that is directly exposed to the costs of these weather risks is the short-term insurance industry, since this industry pays out claims caused by weather perils (Mills, 2007b). Short-term insurers in South Africa have already started experiencing the impacts of weather-related losses or claims on their businesses (FSB, 2012). On that note, the subsection that follows will provide an overview of the effects of weather-related losses on the short-term insurance industry.

2.7.3.Effects of Weather Events on South African Short-term Insurance Industry Claims

Climate change is expected to increase the risk of weather disasters such as droughts, floods, and storms in South Africa. Therefore, it is anticipated that the demand for weather disaster insurance will increase in South Africa. The aforementioned revelations are bolstered by studies which indicate that there are numerous opportunities for the development of weather disaster insurance markets (Botzen and Van den Bergh, 2012). In prior discussions, it was observed that climate change has caused different consequences in different areas and regions. It has caused material and infrastructure damage and insurance coverage; therefore, it still remains the best way to face the consequences of climate change (Benoist, 2007). Every class of short-term insurance operations is vulnerable to weather risks. This is evidenced by weather events that have happened in the last decade. These events have caused insurers to change insurance rates in order to make underwriting profitable and be able to reserve adequate resources to cover losses (Viscusi and Born, 2006). Climate risks are now difficult to insure, as losses can be huge and much additional capital might be required (Charpentier, 2008). This is because the insurance industry's ability to predict future events and costs is based on current market trends. Therefore, if weather risks are not sufficiently taken into account, premiums will be incorrectly allocated, and future claims might exceed expected levels (KPMG, 2012).

Climate change continues to create new insurance risks (Odeku, 2012). Storms, fires, and floods are predicted to increase in either severity or frequency, and the damages have the potential to reduce the insurer's capacity to calculate prices and spread weather-related risks (Hawker, 2007). Weather events are increasing insurers' risks and claims, and negatively affecting their profitability; hence, some are beginning to take these emerging patterns into account when formulating their business strategy (Logue and Ben-Shahar, 2015). Reviewed literature seems to confirm that there is a high probability of a causal correlation between climate change and weather-related catastrophes. These weather disasters are likely to continue to have a profound impact on societies in terms of property damages and destruction (Gurenko, 2007). The profound impact can be seen in how climate change has been an important subject in the insurance industry to such an extent that the global cost of weather losses is projected to reach over US$1 trillion yearly by 2040. The effects of climate change could be worse in developing countries. Accordingly, insurers have a responsibility as ubiquitous players in society to assist in the mitigation of these risks and in shaping climate change policies (Dlugolecki, 2008).

Insurance remains a critical risk management tool used to protect and support the well-being and growth of an economy. For example, it is estimated that from 1980 to 2003 insurers covered 4% of the total costs of weather-related disasters in low-income countries and 40% in high-income countries (Mills, 2007b). The short-term insurance industry carries risks associated with insuring or protecting private and public infrastructure or assets. If these assets or infrastructure are destroyed by weather-related conditions, the first industry to suffer the cost of consequences is the short-term insurance sector which has to fork out millions of rands to indemnify the insured. This evidenced by the rise in insurance payments relating to climatic events, which have increased fifteenfold over the past 30 years (Ceres, 2012).

The increase in insurance payments towards the above-mentioned weather disasters have long-lasting effects on the finance, capital structure, shareholders' value, and profitability of insurers (Tucker, 1997). Santam, a leading short-term insurer in South Africa, revealed that climate change is one of the systemic risks that have a profound impact on how valuables and assets are insured (Santam, 2011). Consequently, if insurance businesses' viability and sustainability is threatened, this will have negative effects on economies and societies that rely on insurers for protection from fortuitous events.

South Africa has been suffering from the effects of extreme weather on a more regular basis over the past years (Aon Insurance Brokers, 2013). The South African insurance sector is also facing climate change challenges and insurgency in weather disasters (hailstorms, floods, and fire damages) which have been costly and negatively affecting underwriting margins (FSB, 2012). Local insurers experienced unprecedented weather-related losses that worsened their claims ratios (PricewaterhouseCoopers [PwC], 2014).

Climate change is presenting insurers with new challenges of dealing with the myriad of weather claims as a result of damage to both movable and immovable property.In 2010, South African insurers dealt with an increase in corporate claims resulting from weather-related events (Mutual & Federal, 2010). Heavy rains and storms led to an influx of claims for damage to residential and commercial properties. In 2011, flooding in eight of South Africa's provinces damaged properties and interrupted business activities (Samuhel, 2011). Severe flood damage was also reported across South Africa in 2012 and 2013. Some areas in provinces such as Western, Northern and Eastern Cape are becoming more susceptible to flooding (Motor Underwriting Agency, 2014). In 2012, Gauteng was also hit by hailstorms, and more than 25,000 claims were filed across each incident, and the cost of damages was estimated to have been in excess of R1 billion (Aon Insurance Brokers, 2013).

The South African Insurance Association also concurred that in 2012 and 2013 significant and costly weather damages to vehicles, property, and agricultural crops were experienced in South Africa (South African Insurance Association & Insurance Institute of South Africa, 2014). In 2013, a hailstorm occurred in Gauteng, and Santam received more than 2,000 claims with an estimated value of R60 million (Hofmeyr, 2014). Santam indicated that it paid out R188 million and R225 million towards hail claims only in 2012 and 2013 respectively (Santam, 2013). In aggregate terms, Santam indicated that it incurred R475 million towards weather-related catastrophe losses in 2012. Mutual & Federal also reported that its claims costs for hail and fire claims amounted to R345 million. Outsurance also indicated that it incurred about R180 million towards weather-related claims for the same period. Similarly, Absa indicated that it experienced an increase in weather-related claims for both commercial and personal lines portfolios in the last quarter of 2012 (PwC, 2013). Local insurers experienced significant increases in both commercial and personal lines claims compared to 2011. Overall, the industry experienced unusual increases in weather losses in 2012 estimated at R2 billion compared to R1 billion in 2011. The insurer underwriting margins were negatively affected, from 9.3% in 2011 to 4.6% in 2012 (PwC, 2013; FSB, 2012).

The trend in weather-related losses has also persisted. According to Standard Bank Insurance Services (2013), the number and rand value of weather insurance claims increased dramatically. The bank experienced about a 50% increase in weather-related motor and household insurance claims and further highlighted that the level of claims was not sustainable for the industry in general (Standard Bank Insurance Services, 2013). Aon also reported that hailstones in Gauteng in 2013 were severe and larger than walnuts, damaging cars and property (Aon Insurance Brokers, 2013). As a result, the industry's overall claims ratio increased from 62%, 66%, and 68% in 2011, 2012, and 2013 respectively. Industry weather catastrophe losses were estimated to be R2.5 billion in 2013, compared to R2 billion in 2012 (PwC, 2014).

The above-mentioned trends reveal that climate change is a real threat, and the insurance sector should be prepared and have enough financial reserves to deal with the costs of increasing incidences of disasters. Insurers should review their risk management practices, solvency, pricing and risk pooling models, taking into account climatic risks. For short-term insurers to be able to effectively incorporate climate risks into their business models, the relationship between weather-related events and claims should be known and scientifically established. However, empirical studies analysed suggest that climate change and weather affect the short-term insurance industry. Five studies reviewed showed that weather events affect insurance claims. A summary of the models or studies carried out in other countries that have been reviewed will be presented in the next section.

2.8. Empirical Evidence of Climate Change and Short-term Insurance

It has been difficult to find a number of empirical studies pertaining to the interaction between climate change impacts and insurance services. However, at least six studies can be found in literature that have a bearing on this study. The studies used different methods of research and analysis. The first study which was also explained in chapter 1 examined the effects of changes in weather events on loss ratios for crop insurance in New Jersey. It revealed that increase is adverse weather patterns can also increase insurance payouts in weather-sensitive sectors such as agriculture. In addition, the study established that there is an association between changes in weather variables (drought, cold weather, and excessive rainfall) and crop insurance losses. The study confirmed that increasing incidences of insurance losses could be attributed to increased climate variability (Mafoua and Turvey, 2004). The New Jersey study primarily focused on crop insurance while this study will consider aggregate weather losses from all catergories of short term insurance.

The second study is by Scheel, Ferkingstad, Frigessi, Haug, Hinnerichsen and Meze-Hausken (2013) that used the Bayesian hierarchical model with a spatial variable selection to investigate the effect of weather on insurance claims. This methodology was used to explain spatial variability of insurance claims due to weather using generalised linear models in municipalities of central and southern Norway. Essentially, the model used a Bayesian hierarchical statistical approach to explain and predict insurance losses due to weather events at a local geographic scale (in this instance, at municipality level). It is not certain whether this method will work for a country-level study which contains population level data and sample data. The study is also dependent on a good database of insurance claims and climate models; therefore, the complexity of the model is doable when such information is availed.

The third study on the implications for agriculture and insurance was conducted in Netherlands using the Tobit statistical model. The study investigated the relationship between climate indicators and agricultural insured hailstorm damage from 1990 and 2006. The Tobit estimation models used climatic data obtained from the Netherlands Meteorological Institute and Hagelunie insurance company, which had 76% market share (Botzen, *et al*; 2009). While the findings of the model indicated a positive relationship between hailstorm damage claims and climate variables, it should be noted that the study focused on hail damage and used insurance data from one insurance company. This study will focus on all types of weather insurance losses experienced by the South Africa industry.

The fourth study on the influence of weather on the Nairobi insurance industry used regression analysis. It examined the relationship between rainfall and losses in revenue suffered by property owners. The study utilised both domestic and industrial insurance claims that insurance companies paid out from 1997 to 2000. The study concluded that projected future insurance claims might depend on the frequency and severity of weather events. The findings showed that extreme weather events had a direct effect on the extent of property damages, and the study focused on property insurance, maintenance, location and design (Ocholla,Muthama & Owino,2006).

This study will focus on the aggregate weather insurance claims from all classes of insurance. A fourth study on 2004 and 2005 hurricane data in Atlantic was done using statistical analysis models. It evaluated the on the effects of wind speed and duration on building damage. The findings showed that wind speed and duration can significantly affect building damage claims. Other factors such as building variability and vulnerability should be considered (Jain, Guin, & He, 2009). The Atlantic study focused on building damage, while this study will focus on all insurance classes.

The fifth study focused on the occurrence of rainstorm damage based on home insurance and weather data. Extreme weather events such as heavy rainfall cause damages to insured buildings and contents. This study was conducted for Rotterdam, the second-largest city in the Netherlands. Water-related claims (3,100) for insurance damage for seven years (2007 to 2013) was obtained from the Achmea Insurance Group, a Dutch insurance company. Weather variables that were used are rainfall volume and maximum rainfall intensity, maximum temperature, daily averaged wind speed, maximum hourly wind speed and wind gust. A logistic regression model was used to test the significance of weather variables in explaining the occurrence of precipitation-related claims. The analysis was modelled based on the empirical probability that precipitation-related claims were a function of these weather variables. The findings of the study showed that high summer temperatures were positively correlated with the occurrence of precipitation-related claims. The results also showed that weather variables were very important in explaining the occurrence of precipitation-related claims. However, other factors such as the drainage, sewer system, and building structure were considered, as they contribute to vulnerability and exposure to losses (Spekkers, Clemens & Ten Veldhuis,2015). Similarly, this study will use temperature, precipitation, and wind speed as weather variables that influence weather-related claims.

The Rotterdam study focused on non-motor claims (buildings and contents). This study is for the South African short-term insurance industry and will focus on aggregate weather-related claims received by the industry. This will provide the basis for generalisation of the findings, as weather events also affect motor insurance.

The sixth study dealt with climate change and the increased risk in the insurance industry in Australia. Nguyen (2013) outlined that a pattern of rising weather-related claims was observed in Australia, and this study was conducted to validate this trend. The study was aimed at evaluating the relationship between climate change and catastrophe claims costs for the Australian insurance sector. It was premised on the assumption that there were several climate change variables such as average number of hot days, cold or hot nights, cold days, annual sea surface temperature and rainfall that affect insurance claims. Further to this, the study recognised that these variables have multicollinearity; hence, it was unnecessary to include all of them, as one predictor could represent other variables. It eliminated most of the insignificant variables and remained with sea surface temperature as the major variable, which was regressed against claims costs. The regression model results showed that insurance claims costs were positively correlated with the sea surface temperature. This suggested that hot temperatures significantly contribute to an increase in claims costs. The results were found to be in line with climate and weather patterns in Australia where prolonged hot temperatures, heat waves, high winds, and low rain contributed to widespread bush fires. The statistical analysis model also showed that increases in temperatures lead to the rise in intensity and frequency of weather disasters causing financial losses in the insurance industry. The study further alluded to the fact that although climatic risks were real and increasing, socio-economic factors such as economic and population growth also play a role in influencing insurance claims (Nguyen, 2013).

Some non-socio-economic factors such as economic growth and insurance penetration will be taken into account in this study. Their role in influencing weather losses is also important and should not be undermined. This study will utilise insurance premiums or insurance penetration growth as non-climatic variables that drive vulnerability and exposure. The variables will represent or be a proxy to wealth and insurance demand. Based on the reviewed empirical models, similar studies can be carried out in South Africa; nevertheless, the challenge is that insured weather-related losses data is still limited. This is due to the competitive nature of the local insurance industry and the fact that climate change research is not yet a top priority for some local insurers. However, this study will provide a basis for future research that seeks to quantify and evaluate the significance of climate change on insurance claims in South Africa.

The aforementioned models investigated the impacts of change in climatic variables on various classes of short-term insurance weather claims. The studies used different quantitative research methodologies. The common climatic variables used in the studies were precipitation and rainfall. Other variables used to augment and elaborate the models were drainage runoff, property maintenance, location and design, as well as socio-economic factors. Similar to the local insurance industry, the studies also revealed that weather-related insurance claims are not yet well recorded and documented. The unavailability and incompleteness of short-term insurance data also influenced the research models used. The different empirical studies confirmed that there is a positive relationship between change in climatic variables (weather elements) and change in insurance claims.

Additionally ,it is also widely accepted that climate change and variability contributed to the increase in frequency and severity of weather related events since 1980 (Stephenson,2007).A report by Aon also reveal that recent increase in the cost global disasters can be attributed to increase in weather events such floods and storms. In 2016 the total economic losses from natural disasters were USD 210 billion, floods and storms accounted for 45% of the losses (Aon,2017). Recent weather damage or loss trends insinuate that climate variability is linked to variability in damages to insured assets (Tucker, 1997). Further research is still required to clearly distinguish the extent to which climate change have increased insured weather losses or claims.However the reviewed studies and literature in this study demonstrate that climate change can significantly influence change in weather conditions, and consequently severity and frequency of weather damages claims.

2.9. Summary

In recent times, climate change has become one of the most debated environmental issues and major global risk that needs urgent attention. The earth's climate is dynamic and naturally variable. It can be affected by natural factors, such as changes in volcanic activity and emissions, continental drift, solar output or irradiance, and the earth's orbit or oscillations around the sun. Human activity and socio-economic factors have also accelerated climate change due to emissions of greenhouse gases that are accumulating in the atmosphere and increasing global warming. Therefore, both natural and human factors contribute to climate change, but human activities are the main causes of contemporary global warming and climate change.

Climate change is predicted to increase the frequency of high-intensity weather events such as heat waves or spells, very high temperatures, torrential rainfall events, hails and wind storms, flooding, and droughts depending on regions. The projected rise in weather-related damages is likely to have considerable effects on societies and businesses, and the insurance sector in particular. Climate change-related damages are becoming more common and presenting significant challenges to financial markets such as short-term insurance and risk management that provide protection against weather-related losses. This study will focus on short-term insurance, which assists policyholders with recovery in the aftermath of a disaster. An increase in weather losses can lead to a rise in correlated insurance claims, threatening the availability and affordability of weather insurance. On the contrary, the effects of climate change are not entirely negative. They can lead to new innovations, and growth of existing markets and development of new markets to ensure availability and affordability of climate risk insurance.

As the global climate continues to change, developing countries such as South Africa also face an increase in losses from weather-related events. These weather disasters are likely to continue to have a profound impact on societies in terms of property damages and destruction. Thus, it is anticipated that the demand for weather disaster insurance will increase in South Africa. The South African short-term insurance industry has also been dealing with an influx of insurance claims resulting from extreme weather patterns. A leading short-term insurer in South Africa revealed that climate change has become a systemic risk affecting how assets can be insured. Local leading insurers such as Santam, Mutual & Federal, Outsurance, and Hollard are experiencing unprecedented weather-related losses which worsened their claims ratios.

Six empirical studies on climate change and short-term insurance carried out in Norway, Netherlands, Nairobi, and Australia showed that weather events affect insurance claims. Although it has been difficult to find empirical studies pertaining to the interaction between climate change impacts and insurance services, at least these six studies found in literature have a bearing on this study. The studies used different quantitative research methodologies. The unavailability and incompleteness of short-term insurance data influenced the research models used. Therefore, this study is based on these empirical studies conducted in other countries.

The next chapter will provide a detailed account and description of how the study was conducted. It will also explain the methodologies used to collect, analyse, and present data.

CHAPTER 3: RESEARCH METHODOLOGY

3.1. Introduction

The preceding chapter reviewed literature pertinent to this study. This chapter will provide a detailed description of research methods used in conducting the study. It will discuss how the quantitative design, correlation, causal approach, and statistical parameters and models were utilised to collect and analyse secondary data to understand the phenomena under study.

Research method refers to various procedures and methods used in research to collect, interpret and analyse data (Rajasekar, Philominathan & Chinnathambi, 2013). This chapter outlines the research procedures, instruments, methods, and designs that were employed in conducting the study and collection of data. It also provides information on how findings were analysed and presented. This study was carried out to establish and understand the relationships and significance of climate change on short-term insurance weather damages or losses. Therefore, the study investigated both causality and correlations.

3.2. Research Design

According to Zikmund (1994), a research design is a master plan specifying the methods and procedures for collecting and analysing needed data. A research design guides researchers on how to collect, analyse, and interpret observations (Degu and Yigzaw, 2006). It details processes and procedures that will be followed in the collection and analysis of data. It facilitates research operations and work so that research objectives can be achieved (Kothari, 2004).

3.2.1. Quantitative Research Method

The method uses numbers or numerical data that can be analysed using statistical procedures. The gathered numerical data should be measurable so that numbers can be analysed by statistical procedures or mathematical methods (Creswell, 2013). Quantitative research method uses statistical procedures based on theory or hypothesis. It is used to test objectivity of theories through examining relationships (Rajasekar, *et al*; 2013). In this study, it was used to explain relationships between specified climate change variables and insured weather-related losses. According to Creswell (2013), quantitative design deals with causation between independent and dependent variables and makes an inference to observed data.

There have been debates that climate change is increasing weather-related insurance claims in South Africa. Publications by reputable and leading local insurers over the past years demonstrated that there has been an increase in weather-related claims. It is therefore the researcher's view that a quantitative analysis is required to verify if climate change has influence on weather claims or not. This study attempted to answer the research objectives and hypotheses outlined in Sections 1.4 and 1.5, using quantitative research techniques. The study employed econometric models to statistically establish the direction, magnitude, and strength of the relationship between changes in climatic variable and weather losses. Empirical evidence of similar studies on the subject was also reviewed to support the use of this research method. These studies supported the need to quantitatively measure the observed data or theories to prove or disprove if climate change influences weather damages. This was achieved by analysing changes in climate variables such as temperature, rainfall, and wind speed in relation to weather-related costs incurred by insurers from 1980 to 2015. The data used was obtained from published and unpublished weather, economic and insurance market sources.

In adopting a quantitative approach for this study, various pros and cons were considered. The pros for the design in relation to this study are as follows: First, a quantitative research method made it easier to test hypotheses proposed in this study as outlined in Section 1.4. Secondly, the quantitative research was utilised to assist in establishing causality between climatic variable (independent) and weather-related claims (dependent). Thirdly, the design used statistical methods and more so the data used was obtained from reliable sources such as the South African Weather Service, the South African Insurance Association, and the FSB. These are weather authorities and short-term insurance industry regulatory bodies respectively. Therefore, the information used is not based on assertions but on relevant market trends. Hence, results of the research can be viewed as more reliable, objective, and unbiased. With regard to the cons of the adopted quantitative research, only one could be found. Quantitative research requires extensive statistical analysis, which could be difficult for researchers that are not statisticians.

The research design in this study employed controls to allow testing of the proposed research hypothesis and causation. It assisted in explaining the behaviour between climatic variables and weather-related claims. The research findings were mathematically tested in terms of reliability and validity to confirm or refute the assertion that climate change affects weather-related claims. Statistical analyses were crucial in arriving at objective research conclusions that can be relied on. However, the extensive statistical analysis was difficult and involved consulting statisticians. As a result, it was more expensive and required much time to perform statistical analysis.

3.2.2. Methods of Analysis Employed – Correlation and Causal

Correlation analysis is used to establish if there is any association or a relationship between variables. It can be used to determine the extent to which variables change together to better understand events and predict outcomes. The relationships can be weak or strong and negative or positive. Correlation does not show causality (Simon and Goes, 2011; Gujarati, 2004). Correlation analysis was important for this study because it provided a starting point for investigating the relationship between climate change impact and short-term weather insurance. It also provided a way to determine the strength and direction of the relationship between weather changes and insurance claims. The correlation analysis will be crucial for future research on the impact of climate change on insurance claims. The drawback of a correlation study is that it can only be used to establish relationships. It does not give further information on causality and the reason for such a relationship. In an attempt to understand the research phenomenon, this study also went further to detect causality between climate change or weather damages and insurance claims. Although the study focused on correlation, it used a combination of correlation and causality research in order to gain a better understanding of the phenomenon.

Causal analysis is conducted to identify the cause-effect relationship among narrowly defined variables. It helps to infer causality, concomitant variation of variables, and to establish the appropriate causal order between dependent and independent variables (Zikmund, 1994). Causal analysis seeks to show how one or more variables affect changes in another variable in order to understand if functional relationships exist between two or more variables. Causal analysis can be used to examine the existence and extent of cause-effect relationships in an attempt to assess impacts of specific changes on existing problems or phenomena. To establish causality, it is crucial to observe variation in the variable that is assumed to cause the change in the other variable(s), and then measure the changes (Kothari, 2004). Therefore, causal analysis was used in this study to determine if climate change has an effect on weather-related insurance claims.

Causal analysis assists in showing concomitant variation in the occurrence of weather-related claims. Concomitant variation is the extent to which independent variables cause an effect to occur on the dependent variable or vary together as predicted (Zikmund, 1994). However, in a complex environment, it is difficult to identify the causal factor or events, since they could be many. Therefore, this analysis was used in the study with the purpose of inferring causality and to

- establish the appropriate relationship between climatic factors and short-term insurance claims;
- measure the concomitant variation between the presumed climatic factors and presumed effect on weather claims; and
- recognise the presence or absence of alternative plausible explanations or causal factors of short-term insurance claims.

However, it should be noted that even if the three criteria of causation are present, the researcher can never be certain that the causal explanation is adequate.

The research design for this study was chosen because of the following two main advantages for this study: (1) it was instrumental in identifying changes in trends or patterns of weather-related losses or claims in relation to climate change, and (2) it was found that it can be relied on to test if there is a relationship between weather claims and climate change, since it is associated with high levels of internal validity due to systematic selection of research units.

Given the foregoing advantages, the following were recognised as two major drawbacks or disadvantages of the research design used: (1) coincidental events can be attributed as cause-effect relationships, as insurers have always incurred weather damages before climate change became a topical matter, and (2) socio-economic factors can affect weather losses; hence, causality between climatic factors and claims could be misleading. For example, weather-related claims could be affected by changes in people’s wealth, size of the insurance market, economic growth, and population growth. In some instances, it might be difficult to conclude with certainty which variable is a cause and effect. Thus, this study was also used to assess the existence and strength of causation between climate change and weather claims.

3.2.3. Proposed Research Model versus Empirical Evidence

The proposed research model that was used in this study was informed or guided by six similar studies conducted in other countries. The common variables used in these models are insurance claims data (dependent variable), temperature, precipitation, rainfall, and wind speed (independent variables). These studies are summarised in Table 3.1.

Table 3.1: Empirical Evidence on Climate Change and Insurance Claims

Country	Model	Topic	Variables	Results
Norway (Scheel, *et al*; 2013)	The Bayesian hierarchical model (regression model)	The effect of weather on insurance claims	Temperature, precipitation, drainage runoff, snow water, and insurance claims	It confirmed that there is a positive relationship between weather and change in insurance claims
New Jersey , (Mafoua and Turvey, 2004)	Econometric Model	The effects of weather events on loss ratios for crop insurance products	Rainfall, temperature, crop insurance loss ratios	It established that there is a link between weather variables and crop insurance losses
Nairobi, Kenya (Ocholla, *et al*; 2006)	Regression Analysis	The influence of weather on the insurance industry in Nairobi	Claims of damaged property, rainfall, temperature, water drainage, property maintenance, property location, property design	Study confirmed that extreme weather events had a direct effect on the extent of property damages
Atlantic Hurricane Season (Jain, *et al*; 2009)	Probability distributions	Statistical Analysis of 2004 and 2005 Hurricane Claims Data	Building damage claims data, wind speed and duration, building locations and vulnerability	It showed that wind speed and duration at a location can affect buildings
Australia (Nguyeni, 2013)	Regression Analysis	Climate change and increased risk in the insurance industry	Weather-related insurance claims cost, sea surface temperature	Increases in the temperature increase intensity and frequency of weather disasters (insurance claims)
Rotterdam, Netherlands (Spekkers, *et al*; 2015)	Logistic Regression	Occurrence of rainstorm damage based on home insurance and weather data	Precipitation-related insurance claims, rainfall, temperature, wind speed, drainage and building structure	Precipitation-related insurance was a function of weather variability

3.3. Methodology

3.3.1. Secondary Data Collection

Secondary data is already collected and readily available data from other sources. The data can be obtained from literature, government records, industry journals, magazines, and some published and unpublished articles or journals (abstraction from documents). Kothari (2004) outlined that secondary data refers to data already collected and analysed by other people or researchers and can be unpublished or published data. Some sources of secondary data used in this study include information released or reported by local and international insurance industry bodies and regulators, institutions such as the South African Reserve Bank, weather authorities, and reputable industry players and organisations.

Advantages of secondary data include the enabling of the researcher to build on past knowledge and experience. In addition, the researcher can obtain data quicker, and data is easier to access and less expensive, since its readily available. All the data used in this study was obtained free of charge. Further, secondary data took away the challenges associated with collecting original data.

The disadvantages of secondary data observed included the fact that collected data was not designed to meet the researcher's needs, since it was previously collected or gathered for other purposes. For example, weather loss data was provided in US dollars and converted into South African rand value based on the average annual US dollar/rand value of R12.75 for the year ending 2015. Weather data in this study was obtained in a monthly format and had to be aggregated and averaged to represent annual changes in weather activities at national level. In some instances, the secondary data (weather and weather claims) was found to be inadequate to achieve the researcher's objectives. In this scenario, the strategic risk forum report from the South African Insurance Association's website provided weather losses data from 1980 to 2013 only. The weather losses for the period 2013 to 2015 were obtained from Aon – Meteorologist department that deals with catastrophe analytics and impact forecasting.

The data had to be interrogated to understand its meaning and limitations. In analysing the data, it was noted that the insured weather losses data was significantly incomplete. There was no data recorded for 17 of the 36 years under study. Both economic and insured losses were not classified to indicate the contribution of each weather peril (flood, storm, hail, drought, wind, and fire) towards the aggregate costs. The data for total economic weather-related costs was complete; no data was found for only one year of the thirty-six years. Therefore, the researcher used aggregate annual economic weather-related costs as a proxy for insured losses. However, secondary data provided a cost-effective way of gaining a broad understanding of the proposed research questions and objectives.

3.3.2.Target Population

Target population is the reference population which the researcher wishes to draw a conclusion from (Degu and Yigzaw, 2006). This study targeted the entire short-term insurance industry in South Africa. There are over 180 short- and long-term insurers, including reinsurers (Financial Services Report, 2014). There are about 99 licensed short-term insurers in South Africa. Based on the services board 2014 annual report, the estimated gross written premium for the short-term insurance industry is about R100 billion, and the total value of investment assets is in the region of R111 billion. The motor and property insurance classes contribute about 70% of the gross annual written industry premiums. In 2013, the industry spent about R40 billion on claims settlement only (FSB, 2013).

3.3.3.Sampling Techniques

Sampling deals with the selection of a number of study units from a defined study population. A sample of the population has to be selected and should be representative of the larger population (Degu and Yigzaw, 2006).

3.3.3.1. Convenience or Opportunity Sampling

A sample is made up of individuals who are the easiest to recruit at the time. It uses data or information from the target population available at the time and willing to take part. It is often based on convenience (Kelley, Clark, Brown & Sitzia, 2003). The study focused entirely on South Africa and the South African short-term insurance industry for the period 1980 to 2015. Furthermore, the study focused on registered short-term insurers only, since they are the direct assumers of weather-related risks and responsible for paying out claims.

Because of the competitive nature of the industry, individual insurers were not willing to disclose comprehensive statistics on weather-related claims paid out. The gross written premium easily accessed from the FSB reports and total economic weather data was already aggregated in annual format. Since the weather-related loss and gross premium statistics were available in aggregated annual terms, the researcher found it imperative to use aggregate average annual climatic figures so that the data sets are in a similar format.

The researcher found that with this sampling technique, the data was gathered quickly and allowed the use of own judgement. The process was less costly and time-consuming. On the contrary, this method could lead to under- or over-representation of insurers that do not record weather-related damages. The researcher could also not probe further but had to utilise the available weather damages data. However, while other sampling methods could have been preferred, convenience sampling was the only technique that could be used to collect the required data.

3.3.4.Data Sources and Collection

In previous sections, it was discovered that weather-related insurance claims are being influenced by climate change and other socio-economic factors. The study targeted some of these important climatic and socio-economic factors that play a critical role in influencing the magnitude and severity of weather-related insurance claims. The weather-related costs or economic costs represent the dependent variable, whereas the climatic factors and economic factors are the independent measures. In terms of research control to reduce errors and to increase sensitivity and statistical validity, other socio-economic factors that influence weather claims such as insurance penetration were included in the model as dependent variables. This was done to normalise and to attempt to attain a natural environment in which insurers operate so as to increase the generalisability of the findings. The subsubsection that follows will provide a description of the data collected.

3.3.4.1. Weather-related Costs or Losses Data Collected

Weather-related losses that were investigated include damage caused by hailstorms, flooding, drought, fire, and wind. The study used total economic weather-related costs as a proxy for insured losses. Economic and insured weather losses data for South Africa from 1980 to 2013 was available and obtained from the Internet. This data is contained in a report that was accessed from the South African Insurance Association's website (Schwarz, 2014). The report provided aggregate annual weather-related losses from 1980 to 2013, both overall losses (economic and insured) for South Africa. The data was presented in a bar graph on page 7 of the report, and the researcher had to extract the data from the graph. Since the data was extracted from the bar graph, it could be viewed as estimated weather losses. The losses were provided in US dollars adjusted to 2013 values based on the local consumer price index. The weather-related losses or costs data was converted into South African rands value based on the average US dollar/rand value for the year ending 2015. The average exchange rate for the year was obtained online from the South African Reserve Bank's statistics,(2016).

The credibility of the weather losses data cannot be questioned, as the report was obtained from the South African Insurance Association, which is a professional body that represents the short-term insurance industry. The association has more than 59 members that should be registered as short-term insurance service providers and also abide by the code of the short-term insurance ombudsman. The body promotes and represents the interests of the short-term insurance industry, through leading and enhancing efforts for the industry to become recognised and trusted as an important contributor to the South African economy and society.

The source of the weather-related data and information used to compile the report was the 2014 Munich Re Geo-risk research report. This was obtained from the National Catastrophe Service (NatCatService) database established by Munich Re. Munich Re is one of the largest reinsurers in the world with operations in both developed and developing countries. It is one of the leading international short-term insurance carriers. It has been working with several industry players for more than 134 years and assisting them to spread the risk and grow their capacities. As a result of the company's extensive worldwide insurance business operations and footprint, it established the natural catastrophe or disaster database known as the NatCatService. NatCatService has been documenting natural and weather-related losses since 1950 and providing information to the insurance sector and nations. Its data is from more than 200 sources such as weather and geological services, insurance associations or bodies, and scientific and academic centres. The database consists of more than 37,000 data records on natural and weather-related perils. The database is used by researchers, economists, insurance industry players, and politicians in decision-making. Therefore, the data can be viewed as reliable.

However, the report only provided weather data from 1980 to 2013, while this research extended to 2015. The total annual economic losses and some of the recorded insured losses for South Africa from 2014 to 2015 was made available by the Aon – Meteorologist department that deals with catastrophe analytics and impact forecasting. Aon is a leading global and local short-term insurance broker. The meteorological department conducts research, collates and publishes some data on catastrophe and weather-related risks. Therefore, the information was obtained free of charge. The researcher is an employee at Aon, hence had access to details relating to the meteorological department. This information was not considered private, since it does not specifically relate to Aon; thus, no declarations were required. The researcher emailed the associate director at Aon Benfield and requested weather-related data for South Africa. An Excel spreadsheet with data was emailed or provided.

The data obtained from the South African Insurance Association's website and Aon – Meteorologist department did not have economic or insured losses for the year 1997. Both sources did not provide reasons as to why the economic and insured losses for this particular year were not recorded. There was no pattern in the missing value, hence the value was missing at random. The researcher could not conclude whether the missing value was missing because there were no economic weather losses or merely as a result of lack of record keeping. Therefore, the data was left with the missing value, but when loaded on the EViews package for analysis, it automatically excluded the missing value and the number of observations was reduced to 35.

The data also showed that insured weather losses are not properly recorded as evidenced by significant gaps compared to the total economic weather losses. Economic losses take into account both insured and uninsured losses. As such, this study used economic losses as a proxy for insured weather losses. This was based on assumptions that if all the losses were insured, the losses suffered by insurers would be equivalent or close to economic losses. To analyse this data, multiple regression analysis was used. The multiple regression models were estimated using the climatic and economic weather losses as variables that are assumed to have a correlation with weather-related insurance losses.

3.3.4.2. Weather Data Collected

The study used annual data sets for the period 1980 to 2015. Average annual maximum temperatures (in degrees Celsius), average annual rainfall (mm), and average annual wind speeds (meters/second) were used to capture the climatic variables. The data was collated and averaged so as to obtain the national average statistics to suit the needs of this study. As a result, research models were constructed using data from seven provinces for the period 1980 to 2015. It should be highlighted that the study used weather data from eight weather stations only, yet South Africa has more weather stations.

Changes in these weather variables over time represent changes in climate. Average annual temperatures, precipitation, and wind speed were used to achieve the research objectives. Literature reviewed (Feng, 2013; Voorhees, *et al*; 2011;) in the foregoing sections showed that changes in temperatures, precipitation, and wind speed over time have been influenced by climate change. Therefore, these weather factors are core determinants of climate change in this study. The weather data was obtained from the South African Weather Service. Although some weather data is readily available on the Internet, the researcher decided to approach the South African Weather Service for more reliable data. The South African Weather Service is a public entity under the Department of Environmental Affairs. It is mandated to deal with weather and climate forecasting in South Africa as a member of the World Meteorological Organization. The unit manager for climate information at the South African Weather Service was approached for the data, and a simple disclosure statement was signed by the researcher.

The data from the South African Weather Service was in monthly series. It was aggregated and averaged to represent changes in weather activities at national level. Some provinces could be experiencing more rapid climate change than others, hence averaging assisted in measuring the central tendency of data. South Africa has nine provinces, and data from seven provinces was used in this study. Each province was represented by one major weather station in a specific city except for Gauteng, which was represented by two. The selected weather stations are located in Johannesburg, Pretoria, Cape Town, Durban, East London, Vryburg, Bloemfontein, and Polokwane. The provinces represented are Gauteng, Western Cape, North West, KwaZulu-Natal, Eastern Cape, Free State, and Limpopo respectively. It should be noted that Gauteng was represented by two stations in two cities (Johannesburg and Pretoria) because it is the largest province in terms of population and economic activity; hence, two weather stations were chosen. Aon insurance broker reported that Gauteng is densely populated and built up to such an extent that it constitutes about 35% of exposure to floods and hailstorm damage (Times Live, 2016).

Monthly weather data for each variable from eight major weather stations was provided from 1980 to 2015 for seven provinces, while data for the other two provinces (Mpumalanga and Northern Cape) was from 1994 to 2015. The station manager could not provide complete data from 1980 to 2015 for these two stations in these two provinces.

The weather service department could only provide more complete information or weather data from 1980 to 2015 for seven provinces. There were also a few areas where the weather data provided by the South African Weather Service had missing values in the data set. The data for those specific months only was obtained from the Internet so as to complete the data. For example, temperature data for East London, October 2014 and Bloemfontein, January 1992 to April 1992 were obtained from the internet (WeatherSpark, 2016). The following months were also missing for Pretoria: January 2012 to December 2012, June 2015, July 2015, October 2015, and November 2015 and December 2015. The Pretoria data points were obtained from internet weather websites (WeatherSpark & timeanddate websites,2016).These websites provide useful worldwide weather information data for cities, towns, and countries. However, the data provided by the South African Weather Service was from one weather station in each province, but it is not certain how many stations are used by the websites highlighted when they compiled their data.

The information obtained from the South African Weather Service website, (2016) also showed that the average mean and maximum annual temperature experienced in the south range from 23.3 to 35.0°C. The windiest place in South Africa has an average wind speed of 6.9 m/s. Furthermore, information from AgriSA showed that the total average annual rainfall received by South Africa based on all weather stations in nine provinces is about 608 mm and that 2015 received the lowest average rainfall of about 403 mm (AgriSA, 2016). This shows that on average, each province receives 67.5 mm of rainfall a year. Although this study used only eight weather stations in seven provinces of the country, the sample results that follow seem to reflect similar trends. The average annual temperature data range from 23 to 33°C, the average annual wind speed range from 4 to 5.1 m/s, and the average annual maximum rainfall range from 35 to 74 mm. Therefore, it can be concluded that the weather data used in this study represents the average national weather trends in South Africa.

3.3.4.3. Gross Short-term Insurance Premium Data Collected

The focus of the study was on short-term insurance; hence, factors such as the insurance market size and growth (socio-economic factors) that affect the magnitude and severity of weather losses were also considered. The annual gross written premiums were obtained from the FSB. The FSB is an independent institution established by law to regulate and supervise the South African non-banking financial services industry. The FSB also annually compiles market information for the insurance industry. The gross written premium information is contained in the FSB's annual reports published on its website. These annual market reports were freely accessible from the FSB's website. Furthermore, the researcher was also provided with hard copy annual reports from where gross written premium data for the period from 1980 to 2014 was extracted (FSB,1983,1984,1985,1986,1988,1989,1990,1991,1992,1993,1995,1996,1997,1998,1999, 2000,2001,2002,2003,2004,2005,2006,2007,2008,2009,2010,2011,2012,2013 &-2014).

The gross industry premium for the year 2015 was not yet published at the time the study was undertaken; hence, an estimate was used. PwC 2016 report indicated that the gross written premium of three major insurance companies surveyed (Santam, Outsurance, and Mutual & Federal) show that their combined annual gross written premiums increased by 12% in 2015 (PwC, 2016). Therefore, for the purpose of this study, the 2014 annual gross written premium was adjusted or increased by about 12% to estimate the 2015 gross written premium. The gross annual written premium for the short-term insurance industry was utilised in the regression models. Gross annual written premium represents the growth of the local insurance markets and was used as a proxy for insurance penetration.

3.4. Analysis and Presentation of Results

This section focuses on analysing the secondary data collected to address the objectives of the study. Data analysis and presentation deals with searching for patterns or relationships that might exist amongst data sets to support or refute the research hypotheses and conclusions (Kothari, 2004). The data gathered in this study was analysed through econometric modelling and statistical regression analysis. Data for most relevant study variables was provided in annual terms; as such, the study used annual data for all variables. It became necessary to annually aggregate and average the weather data that was obtained in a monthly format. Three main regression models were used. The first model examined the relationship between weather-related damages and temperature. The second model looked at the link between weather-related damages and precipitation. Finally, the third model examined the relationship between wind speed and weather-related damages.

3.4.1. Techniques for Data Analysis

3.4.1.1. Regression Analysis

Regression analysis is a statistical process for estimating relationships amongst variables. It deals with the statistical dependence of one variable on other variables. Regression can be utilised in measuring the strength or degree of linear association between variables (Gujarati, 2004). This is a linear regression method and can include multiple independent variables. The benefits of using this method are that data analysis on modern computer software is efficient and quick. It is easier to statistically analyse data compared to other regression techniques. Non-statisticians can easily understand and interpret results. However, least squares regression can be unreliable if the data has excessive outliers or extreme ends (Gujarati, 2004; Wilson and Tisdell, 2002). A multiple regression model was constructed in order to interpret quantitative findings of the research.

A multiple linear regression model has more than one independent variable to assess associations between two or more variables. Multivariate analysis is a statistical method that simultaneously analyses more than two variables. It uses multiple regression analysis which allows the researcher to analyse one dependent variable that is presumed to be a function of two or more independent variables. This will help the researcher to verify if there is an association or correlation amongst variables and to what degree. It also helps to check if there is any cause-effect relationship between variables and to what extent. It should be noted that in multiple regression analysis, the regression coefficients become less reliable as the degree of correlation between the independent variables increases. If there is a high degree of correlation between independent variables, it means the problem of multicollinearity exists. In such situations, adding another variable that is correlated with the first could distort the values of the regression coefficients. However, the prediction for the dependent variable can still be made even when multicollinearity is present, but great care should be taken to minimise multicollinearity (Kothari, 2004). Therefore, in undertaking this study, the researcher was also guided by the fact that multicollinearity should be at a minimum.

In this study, the regression model made it possible to analyse the effects of climate change variables on weather claims. It also assisted in establishing any association between weather-related claims and climate change. The statistical analysis was done using Excel and the Eviews 9 software.

The estimated regression function:

$$\boldsymbol{Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \cdots + B_n X_n + \varepsilon_n}$$

where Y is the dependent variable, β is the coefficient of the variable X_n, *and* X_n is the independent variable.

This regression function was transformed into three models that were tested to fulfil the research objectives as stated in Section 1.6:

$$\boldsymbol{Y_F = \beta_o + \beta_1 ATM_1 + \beta_2 GUP_2 + \varepsilon_n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\textbf{(1)}$$

$$\boldsymbol{Y_W = \beta_o + \beta_1 AR_1 + \beta_2 GUP_2 + \varepsilon_n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\textbf{(2)}$$

$$\boldsymbol{Y_F = \beta_o + \beta_1 AWS_1 + \beta_2 GUP_2 + \varepsilon_n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\textbf{(3)}$$

Y is aggregate annual weather-related short-term insured losses

β_o measures the effects of weather-related claims when climate change is zero

ATM is average annual temperatures

AR is annual average annual rainfall

AWS is average annual wind speed

GUP is annual gross written short-term industry premium

$\boldsymbol{\varepsilon_n}$ is disturbance term or white noise

3.5. Reliability and Validity of Results

The methods that follow were used to test and determine the reliability and validity of the model results.

3.5.1. Stationarity, Non-Stationarity, and Unit Root Test

The study is based on time series data. Because of that, it was necessary to check for stationarity of data before analysis could be done. Stationarity refers to a scenario where the joint probability distribution, mean, variance, and autocorrelation (statistical properties) of time series data remains constant or do not change with time. Non-stationarity characterises the natural world, while stationary seldom exists. Economic or weather variables increase or decrease over time; therefore, time series are always trending and changing. Information or events are naturally changing (non-stationary) over time, hence the presence of trends, cycles, or both.

In economic modelling, non-stationarity makes it difficult to predict relationships or forecast trends. Non-stationarity could be a result of the presence of a unit root or deterministic trend such as shocks or cycles. Modelling using least square regression on non-stationary data could provide misleading or biased results (spurious regression). To avoid obtaining unreliable results, non-stationary data should be stationarised (Mahadeva and Robinson, 2004).

Stationarity was an important assumption used in this study to analyse time series data. Stationary models provided more meaningful statistical analysis that can be used to predict future weather-related damages based on historical weather data. If variables with unit roots are regressed against one another, a spurious relationship could be obtained, where t-statistics, R-squared, and Durbin-Watson might be biased. If the research models are based on non-stationary data, the findings could show that variables are related, yet they are totally unrelated. Therefore, the unit root test was used to test whether time series data is stationary or not. Unit root test is the process of checking if time series variables are non-stationary and have a unit root. The null hypothesis is the presence of the unit root, and the alternative hypothesis is the absence thereof. The presence of unit root can lead to false or biased inferences on time series regressions. Unit root tests in this study were performed so that research data could be classified as stationary or non-stationary.

This study used Augmented Dickey and Fuller to test for unit root square. The technique was used to test the presence of a unit root square in the research data. The null hypothesis in Augmented Dickey-Fuller is that there is a unit root and the alternative is that there is no unit root. If the augmented Dickey-Fuller statistic is negative, it shows the presence of a unit root, and if positive, it is evidence against the existence of a unit root. Accepting the null hypothesis means that data is non-stationary and should be differenced to make it stationary. The alternative indicates that data is stationary and does not need to be differenced. Based on this method, the research data was found to be non-stationary, and it was differenced to level one to stationarise it. The stationarised data was used to model the regression analysis. The regression coefficients from the stationarised data were interpreted.

The coefficients show the rate of change of one dependent variable as a function of the independent variable. The signs also show the direction of the relationship or association. If the sign of the coefficient is negative, it indicates that there is an inverse relationship, and if it is positive, it means that the variables move in the same direction. Multilinear regression analysis assisted in detecting the association between climate change variables and weather-related losses. However, for the regression results to be relied on, the diagnostic tests that follow were done to determine if research models did not violate the ordinary least square assumptions.

3.5.1.1. Serial Correlation

Serial correlation is closely related to autocorrelation, i.e. when errors in a particular period continue to affect the variable in future periods. Serial correlation tests were done using Breusch-Godfrey Serial Correlation LM test in this study. This was to determine the validity and desirability of the research models. If the chi-square p-value > 0.05, the model is not suffering from serial correlationthis is desirable for the model. If the chi-square p-value < 0.05, the model suffers from serial correlation; hence, it is not desirable.

3.5.1.2. Heteroskedasticity

This is when the variance of the error terms is different across observations in linear regression models. If there is heteroskedasticity, the standard error of estimates are likely to be biased; hence, ordinary least square (t- and F-statistics) can be misleading. This can lead to wrong inference and conclusions. Therefore, the Breusch-Pagan test was used in this study to test for heteroskedasticity. It states that if the chi-square p-value < 0.05, then there is heteroskedasticity. However, if p>0.05, then there is no heteroskedasticity, and the results or models can be relied on.

3.5.1.3. Normality Test

Normality in statistics refers to the shape of the population under study, whether it is bell-shaped (normally distributed or not). For some statistical tests such as analysis of variance (ANOVA) to be done, the normality assumption should prevail. However, it should be noted that violation of the normality assumption is not a serious matter, based on the fact that normality shows to be asymptotic in large samples. In small samples when carrying out an

ANOVA test, the normality assumption should be met. This study used the Jarque-Bera normality test. If the chi-square distribution and corresponding p-value of Jarque-Bera are lower than zero, the null hypothesis of normality is reject, but if it is greater than zero, it is accepted that there is normality (Gujarati, 2004). In this study, if $p>0.05$, then there is normality, but if $p<0.05$, there is no normality.

Although the aforementioned tests provided some important evidence regarding the relationship of climate and weather-related losses, further tests were conducted to determine the strength and extent of the relationship. Cointegration, Vector Error Correction Model (VECM), and Wald tests were used to evaluate the long-run or short-run relationship and causality. These tests will be explained in the next sections.

3.6. Cointegration and Causality Test

Cointegration test is important when investigating association and causality between variables. Cointegration is when time series variables are integrated. Regressing non-stationary variables could lead to unreliable models, but if the variables are cointegrated, the concern of spurious results is eliminated. Cointegration tests long-term dependence and associations between variables. It provides a way of dealing with non-stationarity in time series data in order to detect spurious or real association. Short- and long-run causality can be investigated using the VECM (Ssekuma, 2011). This study used the Johansen cointegration test to determine the relationship between climatic factors and weather-related damages. Cointegration tests provided a way of utilising non-stationary data, knowing that spurious relations will be detected.

Johansen cointegration test was used in this study because it is most suitable in detecting cointegration in time series models that have more than two variables. It is used to identify the presence and number of cointegrating vectors. In this method, cointegration is detected using the trace or maximum Eigenvalue test. These two tests the null hypothesis of no cointegration against the alternative of cointegration. If there is at least one cointegration vector, then cointegration exists (Royal Swedish Academy of Sciences, 2003). A Johansen cointegration test was done using lag length one, since the data is in annual format. If the probability is less than 0.05 and the trace statistic is larger than the critical statistic, then there is cointegration. If the probability is less than 0.05 and the Max Eigen is more than the critical value, then there is cointegration. The results of the study showed that there was cointegration amongst the variables; hence, a VECM was used to analyse the data.

3.6.1.The Vector Error Correction Model

The presence of cointegration justifies the application of the VECM to test the long- and short-run causality amongst research variables. The VECM. can be applied when cointegration exists amongst variables after a Johansen test has determined the number of cointegration relations. The VECM recognises that deviations from long-run equilibrium are a function of a series of short-run adjustments. Long-run behaviour is determined by short-run adjustments. In VECM analysis, the coefficients will show how variables deviate and adjust to equilibrium. The coefficient signs and level of significance also show the level of long-run relationships (Dhungel, 2014; Pfaff, 2008). VECM was used in this study to investigate the short- and long-run causality between climatic factors and weather damages. The VECM was used to establish the extent to which the long equilibrium relationship between the research variables is derived from short-run dynamics. The statistical tests that follow were done.

3.6.2. Wald Test

This was used to test or identify short-run causality in each of the three research models. The relationship between total weather-related costs and study variables was tested. The chi-square probability value is used to determine if short-run causality exists or not. If the p-value < 0.05, then there is short-run causality, but if $p > 0.05$, then there is no short-run causality.

In addition to the foregoing tests and analysis, the results that follow from both the regression models and VECM were examined. The overall R-squared autocorrelation, t-statistics, and p-values from both models were compared. The research hypotheses were answered based on the outcome derived from a combination of all tests conducted.

3.6.3. Overall R-squared

This tests if the model has statistical errors or not. It determines the goodness of fit of the regression model and measures the proportion of variation in the dependent variable accounted for by all explanatory variables. Adjusted R-squared (R^2) was also used to show the predictive power and test validity of the model. It gives the true and actual value of the collective effect of changes in the explanatory variables on weather-related claims. R-squared should lie between 0 and 100%. A 0% shows that there is no variability in the dependent variable in response to the independent variables. A 100% shows that the model's independent variables explain variability in the dependent variable.

The higher the R-squared, the better, as it also assists in determining the reliability and validity of the model. The measure of the strength of variables in explaining total weather losses in this study will be determined as follows: R-squared of 1-25% means low, 26 -59% means moderate, 60-79% means high, and 80-100% means very high. A good model can have a low value or a bad model can have a high R-squared. If a model has a low R-squared but has significant statistical predictors, conclusions regarding the relationship between variables can still be drawn. However, the R-squared parameter alone cannot determine the soundness of the models; hence, it should be evaluated in conjunction with other tests or parameters.

3.6.4. Autocorrelation Testing

Durbin-Watson was used to test if the residuals from the linear multiple regressions were independent. It was used to test if there is autocorrelation as well. The statistics should be between 0 and 4. If the value is 2, it means that there is no autocorrelation, but if it is approaching 0, then it indicates positive autocorrelation. If it is close to 4, it shows negative autocorrelation.

T-test, F-test and p-values usually show the significance of the coefficient and the confidence level in order to check if the results were not obtained by chance. The determining criterion that was used in this study is a 95% confidence level. Therefore, if p-value of the coefficients < 0.05, then it is significant. If p-value > 0.05, then it insignificant. In this study, the H_o will be accepted and H_a rejected if there is a significant relationship between climate change (temperature, rainfall, and wind) and weather-related loss ($p<0.05$). The null H_o will be rejected and H_a accepted if there is no significant relationship between these climate change factors and weather-related loss ($p>0.05$).

The F-test was used, and the p-value of F was used to determine the significance of the models. If the p-value > 0.05, this shows that the model is not significant, but if the p-value < 0.05, then the model is significant. It tests the overall significance of three models constructed in this study. If the research models (temperature, rainfall, and wind) in relation to weather losses meet the F-test and are significant, it shows that the models and their variables are useful. Significance further shows that climate change variables are jointly important in influencing weather losses. On the other hand, if the research models fail the F-test, it will show that jointly these weather factors do not have a significant influence on weather-related losses.

3.6.5.Hypotheses Testing

Hypotheses are suppositions or predictions to be proved or disproved or formal questions that a researcher would like to resolve. These questions can be tested using scientific methods. Thus, hypotheses testing helped the researcher to make probability statements about a certain parameter(s). While hypotheses may not be proved absolutely, they can become foundations of accepted theories if they have been critically tested or validated. The research hypothesis and questions were interested in testing if there is any correlation and significance of the relationship between climatic factors and weather-related damages. Therefore, the parameters that follow were utilised in the study.

3.7. Structure of Methodology

The foregoing sections have provided a detailed explanation of how the study was undertaken. Table 3.2 summarises the structure of the research methodology and gives a clear picture and understanding of all the steps followed in conducting the research and analysing the results.

Table 3.2: Structure of Methodology

Problem Identification – Hyphothesis
Data Collection and Synthesis
Testing of Data – Unit Root Test – Data Non-stationary
Data Transformation or Stationarisation
Cointegration Test-Variable Cointegrated
Vector Error Correction Model Estimations
Stationarised Data Regressed
Results Analysis and Interpretation

3.8. Research Ethics

The researcher has a moral obligation to strictly protect the rights of research participants, including the right to confidentiality, privacy, anonymity, and withdrawal from the study. The researcher obtained all required permission to conduct the study from the relevant authorities and management. The study was conducted ethically, ensuring adherence to all codes and practices of research ethics. All the research information and data were collected in a transparent manner. All sources of data and processes used in the study were disclosed and acknowledged. The study only used secondary data. Challenges encountered in data collection and how they were overcome was also highlighted. The UNISA research ethical clearance process was also followed and an ethical clearance certifcate was obtained.

3.9. Summary

This study used a correlation and causality approach of analysing data, and it was found that it can be relied upon to test if there is a relationship between weather claims and climate change. Further, the causality approach is associated with high levels of internal validity due to the systematic selection of research units. A quantitative research design was adopted to verify if climate change affects weather claims. The study employed econometric models to statistically establish causation, direction, magnitude, and strength of the relationship between changes in climatic variable and weather losses. This was achieved by analysing changes in climate variables such as temperature, rainfall, and wind speed in relation to weather-related costs incurred by insurers.

The quantitative research design allowed testing of the proposed research hypothesis. The research model study was informed or guided by six similar studies conducted in other countries, of which the details are shown in Table 3.1. The study relied on secondary data and focused entirely on the South African short-term insurance industry for the period 1980 to 2015. The data used in this study was from 1980 to 2015; it was obtained from published and unpublished market and industry sources. The data had to be interrogated to understand its meaning and limitations; however, it provided a cost-effective way of gaining a broad understanding of the proposed research questions and objectives. The data gathered in this study was analysed through econometric modelling and statistical regression analysis. The model used a multiple regression model. All research ethics and procedures were compiled during the process of carrying out this study.

The chapter that follows will focus on a presentation and analysis of the results of this study.

CHAPTER 4: PRESENTATION AND ANALYSIS OF RESULTS

4.1. Introduction

This study focused on South Africa's climate statistics and short-term insurance weather-related losses over a period of 36 years from 1980 to 2015. The foregoing chapter discussed the research methodology employed in this study. Findings of the study will be presented in this chapter, and a detailed interpretation and analysis regarding the research findings will also be provided.

4.1.1.Climate Change Trends for South Africa – 1980 to 2015

Figure 4.1 shows South Africa's average maximum temperature variability from 1980 to 2015. The highest average temperature was recorded in 2015. Cumulatively the trend shows that average maximum temperature in South Africa has been increasing over time. The average change in temperature is consistent with global average increases that are causing climate change concerns amongst scientists. The average global increase in temperature from 1880 to 2012 was observed to be about 0.65 to 1.06°C (IPCC, 2014b). This view was also supported by NASA, which estimated that the average global temperature increased by 0.8°C since 1880 and by about 0.2°C per decade since 1980 (NASA, 2010). In comparison, the research data in Figure 4.1 shows that the average temperature in South Africa increased by about 0.53°C from 1980 to 2014, which is an average of about 0.18°C per decade.

Furthermore, the trend shows that the average maximum temperatures have been fluctuating between 22 and 33°C. However, the overall long-term trend shows that the average temperature in South Africa increased from 1980 to 2015. The fluctuation also shows that temperature does not rise at the same time but might rise or drop in certain years. These changes in temperature levels have contributed to incidents of extreme weather conditions such as droughts, floods, and storms that have been experienced in South Africa during the same period.

Figure 4.1: Average Temperatures (Degrees Celsius) – 1980 to 2015

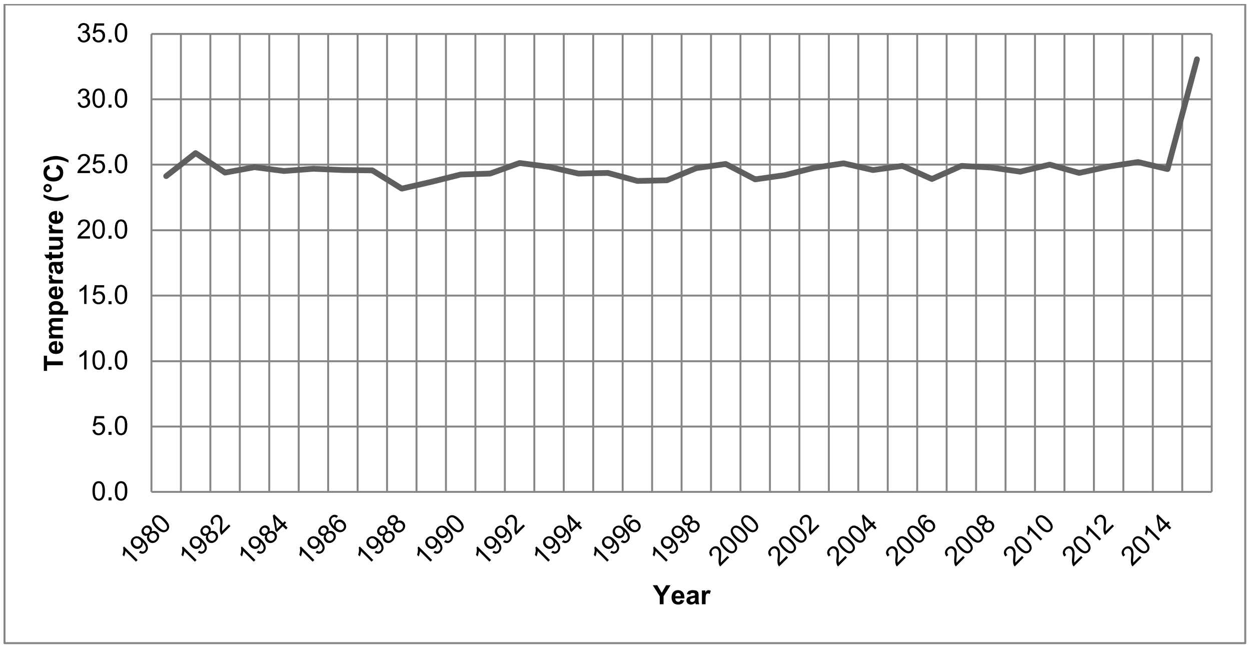


Figure 4.2 shows South Africa's variability in average rainfall experienced from 1980 to 2015. The data shows a fluctuating average rainfall trend between 35 and 74 mm. The average change in rainfall over the period under study shows that there has been a drop in rainfall received by 11.65 mm. The climate data in Figure 4.2 demonstrate that there have been some variations in rainfall received since 1980 in South Africa, with some years receiving more rainfall than others. The rainfall variability, distribution, and intensity influenced the extent of weather-related losses. The data also shows that the highest average rainfall was received in 1988, 1996, 2000, 2006, and 2011. The average least rainfall was received in 1982, 1992, 2003, and 2015. The lowest rainfall was received in 2015, which was also recorded as the hottest year since 1980. In these latter years, the country received below normal rainfall and experienced severe droughts across the country which had significant widespread economic impacts (Theunissen, 2004; Bureau for Food and Agricultural Policy [BFAP], 2016).

Figure 4.2: Average Rainfall – 1980 to 2015

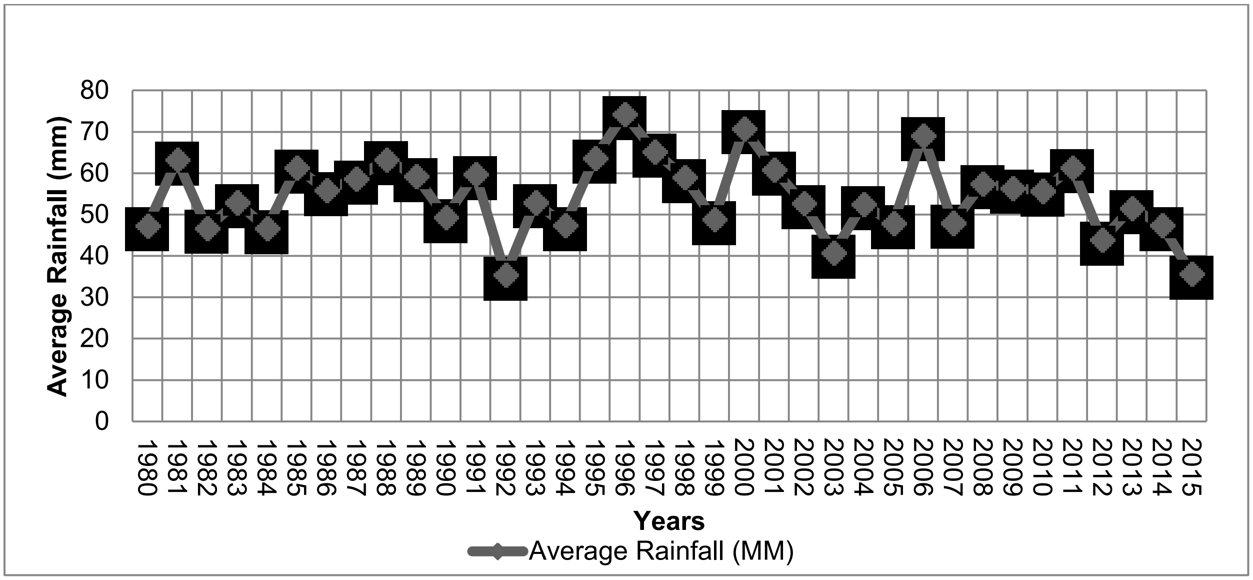
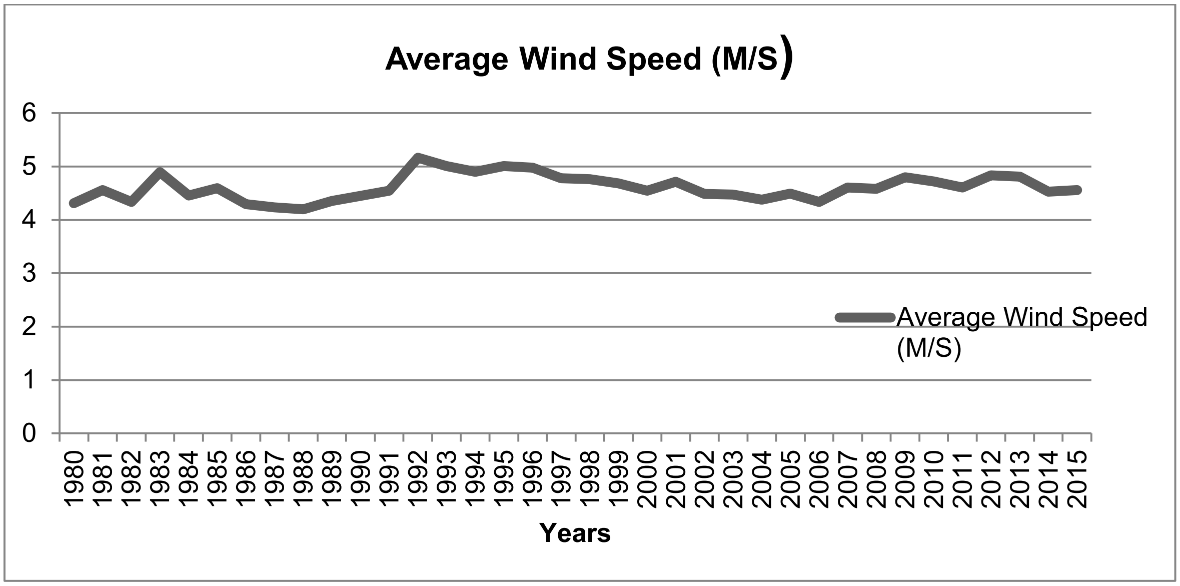


Figure 4.3 illustrates variability in the average wind speed in South Africa from 1980 to 2015. Wind speed of 3.4 to 5.5 m/s (12-19 km/hour) can be described as a gentle breeze on the Beaufort scale that is used to measure wind intensity. This level of intensity causes small waves, twigs or small leaves, and loose paper to be swept off the ground. Figure 4.3 shows that the average wind speed has been fluctuating between 4 and 5.1 m/s, and the average change in wind speed increased by 0.24 m/s. Although the research data indicates that there has been some increase in wind speed intensity, the wind speed levels and magnitude of change show that South Africa is not yet experiencing intense or strong wind speed such as gale forces. Moreover, the level of wind speed is still at a level where it cannot be expected to cause severe damages.

Figure 4.3: Average Wind Speed – 1980 to 2015



The study focused on climate change, but there are also some important non-climate variables that might influence weather losses, such as economic growth and insurance penetration, that were considered. The section that follows will provide an outline of economic data or variables that were used in the study.

In Figure 4.4, the total estimated gross written industry premiums from all classes of insurance in both commercial and personal lines are presented. It is observed that there has been an increase in insurance penetration shown by an increase in gross written industry premiums. The data also indicates strong insurance demand and market growth. The premiums grew from about R1.3 billion in 1980 to about R113 billion in 2015. The sustained growth in written premiums from 1994 can be attributed to a number of factors such as political transformation from apartheid, economic reintegration, increased private sector and foreign investment, transformation of the economy through policies such as broad-based black economic empowerment and employment equity (Sanlam, 2013). These factors led to an increase in economic participation, economic growth, market competitiveness, and insurance penetration, hence growth in written premium. Growth in written premium reflects strong demand for insurance products as well as the extent of risk exposure faced by insurers. In terms of weather-related losses, it can be argued that insurers that have a large client base are likely to receive more weather-related losses. Therefore, as the market grows and policies written increase, the industry could experience an increase in weather-related claims than before.

Figure 4.4: Insurance Penetration – 1980 to 2015

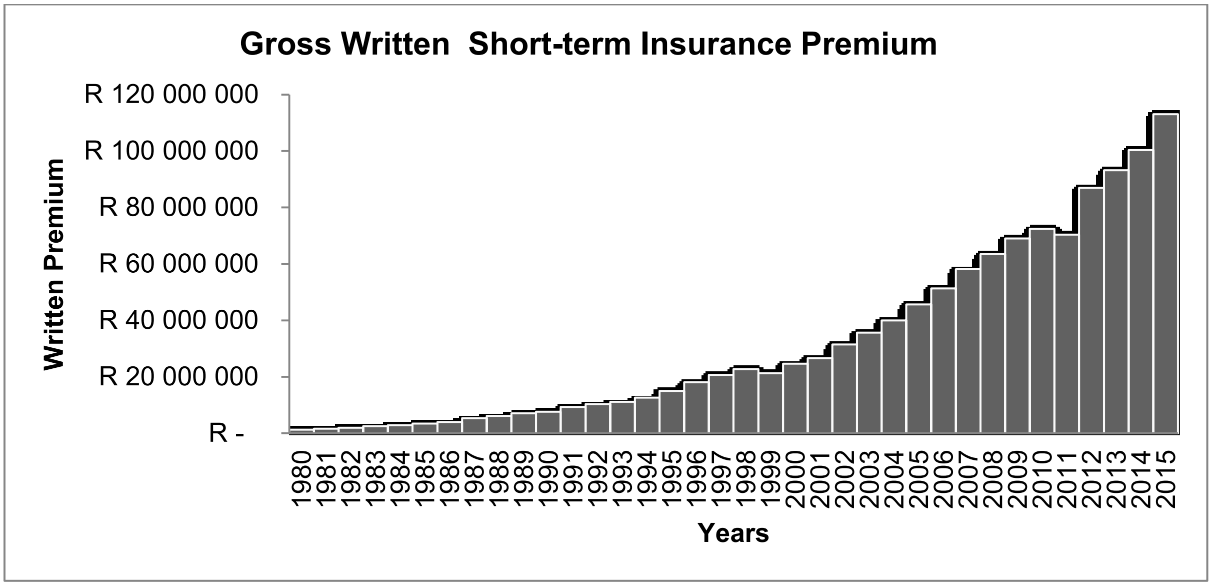


Figure 4.5 shows that some economic weather losses have been recorded since 1980 to 2015 except for 1997. The sources of data used did not have weather-related losses data for the year 1997. This was the only missing data point; hence, it was treated as randomly missing value. When the data was loaded in EViews for analysis, the missing value was automatically excluded; as a result, the study sample size was reduced to 34. However, the economic loss trends still provided a better understanding of the extent of weather losses in South Africa. The data exhibits that the distribution pattern of weather losses since 1980 has been changing, with some years experiencing more damages than others. It also reveals that South Africa is already bearing the burden of quantifiable weather-related losses. The total weather-related costs sustained by the country are estimated to be R148 billion from 1980 to 2015. This is estimated to be about 0.38% of total GDP for the same

period. The costliest losses were in 2015, and they exceeded R26.4 billion. This was due to the severe drought that was experienced across the country.

Furthermore, economic losses from weather events such as floods, storms, and hail have also been occurring with spatial and interannual variability, thus leading to a different magnitude of losses. The variability can be linked to changes in weather conditions and severity. For example, the highest weather losses recorded in 1982, 1992, and 2015 can be attributed to severe droughts that were experienced across South Africa during those years. Literature reviewed in Section 2.7.2 also shows that different provinces experienced extreme weather events such as floods, storms, wildfires, and hail in the period between 2000 and 2014.

Figure 4.5: Estimated Total Weather Losses for South Africa – 1980 to 2015

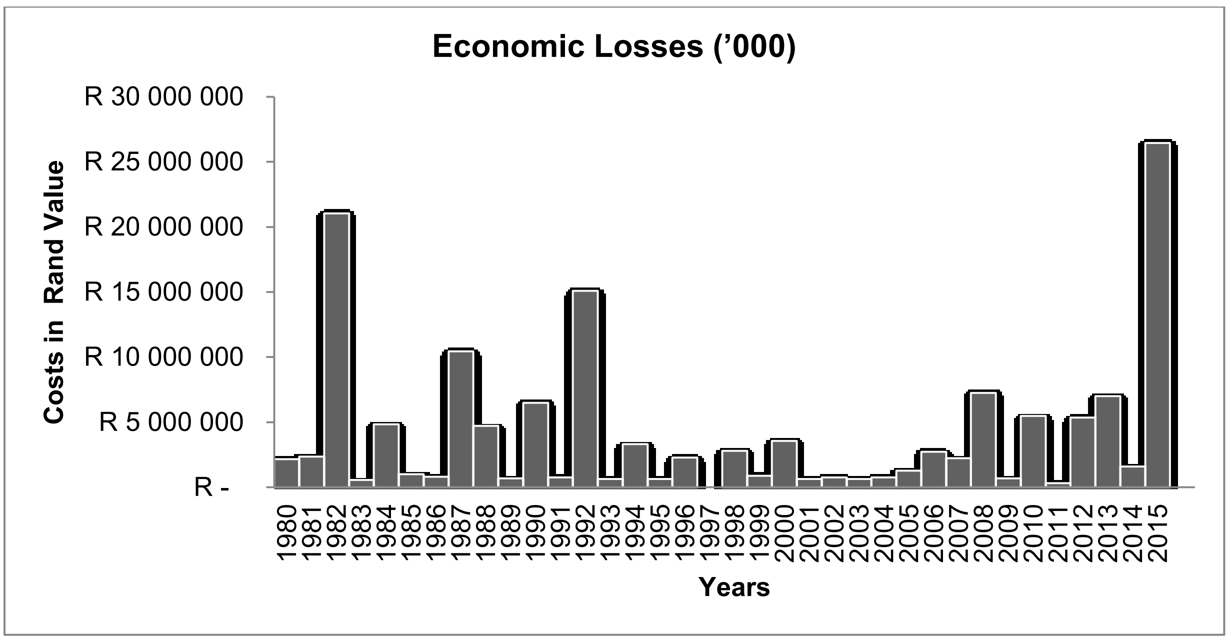
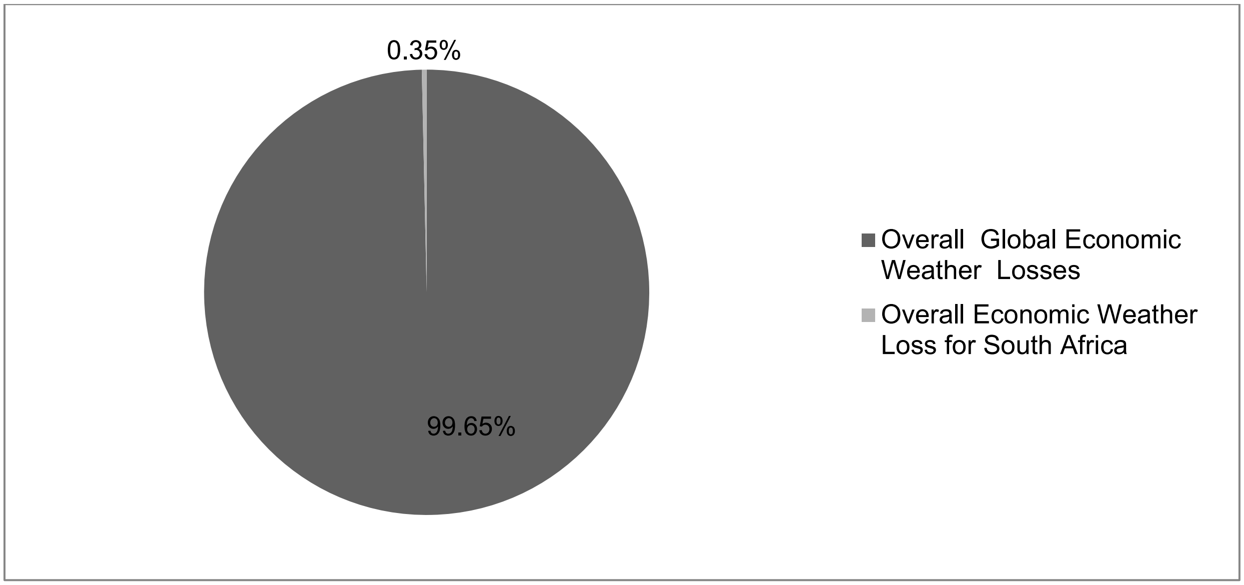


Figure 4.6 confirms the prevalence weather-related losses in South Africa. It shows the proportion of weather-related losses contributed by South Africa to the total global weather losses. The fact that over the past 35 years South Africa has actually contributed about 0.35% to global weather-related losses triggered interest in the research. Also, the literature reviewed in Section 2.7.2 also showed that South Africa is already experiencing

adverse weather conditions such as storms, hail, floods, and droughts. This evidence substantiates that weather-related losses are no longer an imaginary phenomenon in South Africa.

Figure 4.6: South Africa's Estimated Contribution to Global Weather Losses – 1985 to 2015



Source: Munich Re (2015) and Aon Insurance Brokers (2015)

From Figure 4.7, there are 17 years out of the 36 years in which no data was recorded for insured losses. The gaps demonstrate that insured weather losses are not properly recorded. This could be attributed to the competitive nature of the industry; as such, some players are not willing to divulge such data. Although the data had gaps, it still showed that South African insurers have incurred some quantifiable weather-related losses over the 35 years. The total insured weather-related costs incurred by the country are estimated to be R22.5 billion from 1980 to 2015. Although the data is not adequate, it still shows that the insurance industry has been incurring weather losses. The highest recorded insured loss of about R5.1 billion was recorded in 1987. It is however inexplicit as to why 1987 had the highest insured losses recorded compared to other years. It should be noted that the data could be underestimated or overstated because the insured weather loss data is still poorly recorded in South Africa. On the other hand, the gaps in data also demonstrated that more work needs to be done in terms of consistently recording and sharing insured weather-related losses.

Figure 4.7: Insured Weather Losses – 1980 to 2015

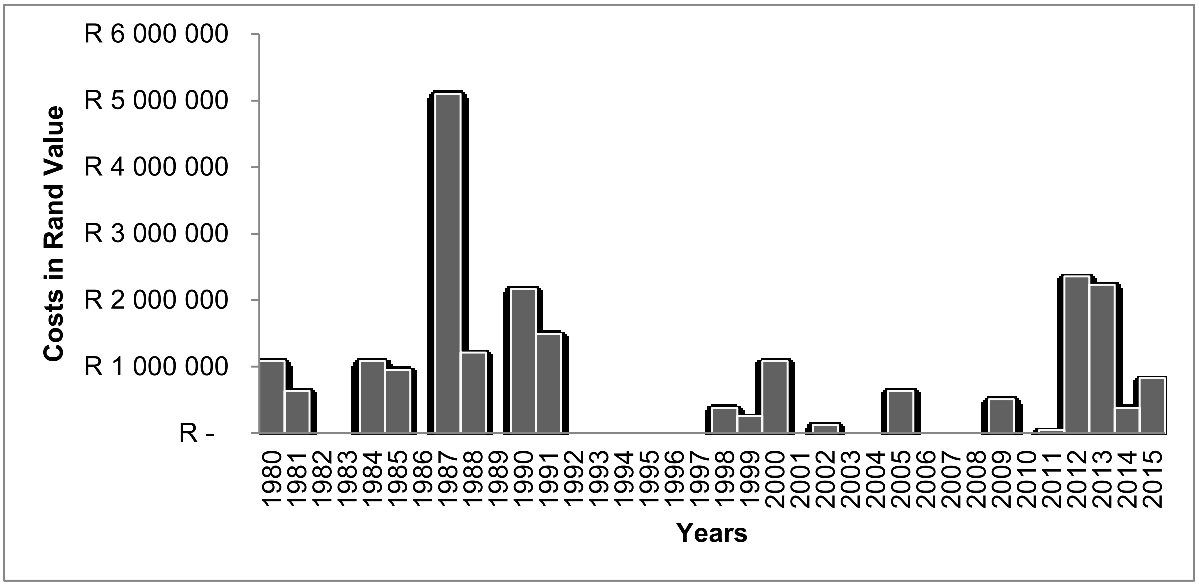
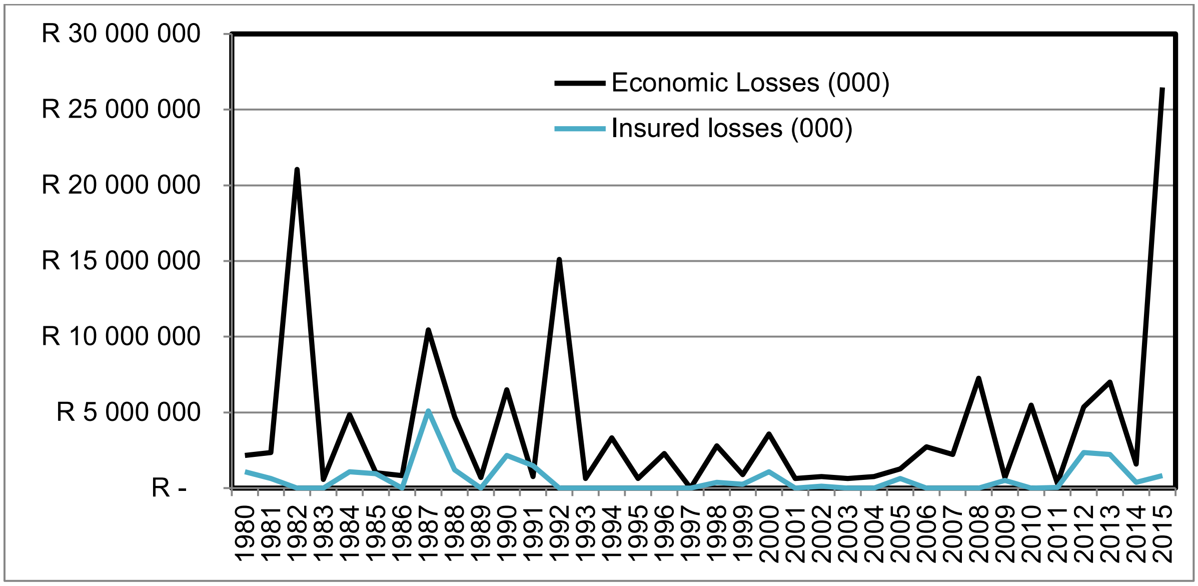


Figure 4.8 shows the total distribution of economic and insured losses from 1980 to 2015. As alluded to in Figure 4.8, the year 2015 recorded the highest total weather losses of about R26.4 billion due to a severe drought that has been described as one of the worst in three decades. This further demonstrates that the severity of weather events can influence the magnitude of weather losses.

The long-term analysis and overall trend of weather-related damages in South Africa reveal that the country has experienced economic and insured weather losses since 1980. The economic costs have been used as a proxy for insured losses or claims and show that weather-related costs can significantly affect the insurance industry. Although the systematic measuring and recording of weather damages is still a challenge, the aforementioned data reflects the costs associated with weather damages. These costs show the possible impact of weather damages in the absence of insurance.

Figure 4.8: Total Economic and Insured Losses



The data displayed in Figures 4.6, 4.7 and 4.8 show that weather-related losses can result in noteworthy costs that can exert pressure on the insurance industry. Understanding the significance of climate change on weather-related losses is crucial for the insurance industry in order to be able to predict possible future losses and costs. It can be observed that there is a pattern amongst the data reviewed and therefore it was important to statistically test the data. From face value, the data trends seem to pinpoint to causation amongst the factors.

However, it will be prudent to do an econometric or regression analysis to test the credibility of the contemporary insurance industry debate that climate change is influencing weather-related claims. In the real world, weather data alone cannot be used to predict possible future weather loss trends without considering economic factors. In a bid to arrive at an objective conclusion, the research models also took into account insurance penetration. The proposed models (which were presented in Chapter 3) were used to test the data that has been described in this chapter, and the results will be presented in the next section. The results of the unit root tests which were done as a starting point to examine data consistency will be outlined first. This will be followed by heteroskedasticity, serial correlation and normality test results that were conducted to test if the data did not violate the ordinary least square assumptions. Thereafter, regression, Johansen cointegration and vector error correction tests results will also be presented and discussed.

4.2. Results of Unit Root Test for Research Variables

Unit root tests are important in order to reduce observational errors and ensure the validity of results. The unit root test was performed on all research variables, both dependent and independent, to test if the time series data is stationary or non-stationary before any analysis could be done. Table 4.1 shows the results for the unit root test for all study variables.

The ADF statistics in Table 4.1 are negative and exceed the critical values at both level and first difference. The time series data for total weather-related losses, average annual temperature, rainfall, wind speed, and gross written premium have a unit root, which is evidence that the data is non-stationary. Therefore, the non-stationary data was stationarised or transformed for regression purposes and analysis. After the data was stationarised, it was fed into the respective models whose results are explained in Section 4.3 to 4.7.

Table 4.1: Unit Root Test Results for All Data Variables

Variables	*ADF t-statistics* *(At Level)*	*ADF t-statistics* *(1st Difference)*
Total Weather-related Losses	-5.748309 (0.0000)	-6.962121 (0.0000)
Critical Values		
1%	-3.632900	-3.646342
5%	-2.948404	-2.954021
10%	-2.612874	-2.615817
Average Annual Temperature	-1.520548 (0.5116)	-4.473669 (0.0011)
Average Annual Rainfall	- 5.098269) (0.0002)	-10.77349 (0.0000)
Average Annual Wind Speed	-3.126174 (0.0337)	-8.908471 (0.0000)
Gross Written Premium	5.411065 (1.000)	-1.557717 (0.4924)

4.3. Diagnostic Model Tests

Table 4.2 provides a summary of diagnostic test results. The tests in Table 4.2 were conducted to verify if the data used in the statistical models was correctly specified. The results can only be inferred if these assumptions hold. The models tested for serial correlation using Breusch-Godfrey Serial Correlation LM test to validate their desirability. The chi-square and corresponding p-values are greater than 0.05. Therefore, the models do not suffer from serial correlation. The presence of heteroskedasticity in a model leads to biased and incorrect conclusions. The Breusch-Pagan-Godfrey test was also carried out to detect if the research models had heteroskedasticity. The observed and corresponding chi-square p-values are greater than 0.05, showing that the models do not suffer from heteroskedasticity problem. The models did not suffer from both serial and heteroskedasticity problem; on that account, they are good and sound. Therefore, the study findings can be relied upon.

The normality test results displayed in Table 4.2 show that some study variables are normally distributed while others are not. The distribution of the of average temperature, gross written premiums, and weather losses in a South African context is skewed, as evidenced by the p-values of the model variables that are less than the set criterion of 0.05. The average annual rainfall and wind speed are normally distributed. Although some variables violated the normality assumption, the absence of normality should not be a major concern because it is influenced by the sample size and is likely to be violated as the size increases (Gujarati, 2004). Therefore, the results obtained from the specified models can be relied on. The diagnostic results presented in Table 4.2 provided the basis for conducting further tests such as regression analysis. The research regression results will be presented and interpreted in the section that follows.

Table 4.2: Diagnostic Results

Temperature Model	**Obs Value**	**Probability**
Serial Correlation	0.457959	0.7953
Heteroskedasticity	6.046503	0.4180
Normality	***Value***	***Probability***
Temperature	973.3838	0.000000
Total Weather Losses	89.43844	0.00000
Gross Written Premium	5.96	0.05076
Rainfall Model	**Obs Value**	**Probability**
Serial Correlation	2.344260	0.3097
Heteroskedasticity	3.487362	0.7457
Normality	***Value***	***Probability***
Rainfall	0.151487	0.927054
Wind Model	**Obs Value**	**Probability**
Serial Correlation	3.480260	0.1755
Heteroskedasticity	2.198845	0.9005
Normality	***Value***	***Probability***
Wind Speed	1.263889	0.531557

4.4. Regression Model Results for All Models

Table 4.3 presents the regression results of all the three study models. The temperature model will be explained first, followed by rainfall and wind speed models results. In the temperature model, a unit change in temperature will cause weather damages to increase by R160,273.40. The sign of the coefficient is positive, which means that there is a positive relationship between temperature (global warming) and weather damages. An increase in temperature will cause an increase in weather losses. The p-value for this model is significant, as shown in Table 4.3, which means temperature is an important determinant of weather losses. The temperature model indicates that there is a negative relationship between gross written premium for short-term insurance and weather-related loss. A unit change in gross written premiums will cause a 1.4% change in weather losses incurred. Thus, an increase in gross premium written as a proxy for market growth can lead to a decrease in weather claims. The t-statistic of and p-value show that gross written premium is not significant. According to this model, as the insurance market grows, it should be expected that weather losses would decrease in South Africa. This relationship was found to be insignificant and therefore will not happen.

The results for the rainfall model in Table 4.3 show that a unit change in rainfall will cause an R57,890.11 change in weather-related damages. The sign of the coefficient is positive, which means that there is a positive relationship between rainfall and weather damages. An increase in rainfall will lead to a rise in weather-related damages. The t-statistic and the corresponding p-value are significant, confirming that rainfall is a very important or significant determinant that influences weather losses. The rainfall model shows that there is a negative or inverse relationship between gross written premium and weather-related loss. A unit change in gross written premiums will cause a 0.0380% change in weather losses incurred. In this model, an increase in gross premium written as a proxy for market growth can lead to a decrease in weather claims. The t-statistic and corresponding p-value in this model show that gross written premium does not have an impact on weather-related losses.

The wind speed model shows that a unit change in wind speed will lead to an R841,482.30 change on weather-related losses. The sign of the coefficient is positive, which means that there is a positive relationship or association between wind speed and weather-related losses. The t-statistic and the corresponding p-value are significant, showing that wind speed is an important determinant of weather losses. This indicates that wind speed changes influence changes in weather-related losses. The model also confirmed that there is a negative relationship between gross written premium and weather-related loss. A unit change in gross written premium will lead to a 1.38% change in weather losses. The t-statistic and corresponding p-value are insignificant. That being the case, gross written premium does not influence weather losses in South Africa.

The R^2 for the temperature, rainfall and wind models were too weak at 2.89%,-7.4% and 1.9% respectively. This low R^2 value indicates that collective changes in the variables in each model will not cause a more that 3% change in weather losses. For this reason, it can be argued that the relationship was found to be weak. This finding prompted the study to move on to the next test, which is the Johansen cointegration and VECM. These tests were used to investigate the existence of long- and short-run relationships or causality in the research models. The Johansen cointegration test was performed to determine the long-run relationship, and the results will be interpreted and explained in the next section.

Table 4.3: Regression Results for All Models

Model	Independent Variable	Coefficient	t-stats	Prob.	DW	R-squared
Temperature	Average Annual Temperature	160,273.4	3.627305	0.0009	2.49000	0.028912
	Gross Written Premium	0.014530	0.560459	0.5788		
Rainfall	Average Annual Rainfall	57,890.11	2.936037	0.0059	2.44086	-0.074462
	Gross Written Premium	-0.000380	-0.014449	0.9886		
Wind Speed	Average Wind speed	841,482.3	3.561132	0.0011	2.48145	0.019017
	Gross Written Premium	-0.013793	-0.528657	0.6005		
Observations	35					
Sample	1980 to 2015					

4.5. Johansen Cointegration Test

The results of the Johansen cointegration test are indicated in Table 4.4. The results in Table 4.4 confirm that there is cointegration in the research models. In the temperature model, trace and Max Eigen tests indicated two cointegrating equations, while in the rainfall model there are three. The results of the wind model also established one cointegrating equation. The p-values of the cointegrating equations were found to be significant in the three models. This demonstrates that there is a long-run relationship amongst variables in all the study models. Based on this discovery, VECM was applied to examine whether or not there is long- or short-run causality amongst independent and dependent variables. Therefore, VECM was applied, and the results that follow were obtained.

Table 4.4: Johansen Cointegration Results

		Temperature	**Model**			
Hypothesised Number of Cointegrating Equations(CE)	Trace Statistic	Critical Value	Prob.	Max Eigen Statistic	Critical Value	Prob.
None	40.61640	29.79707	0.0020	24.69480	21.13162	0.0151
Atmost 1	15.92160	15.49471	0.0431	15.31356	14.26460	0.0340
Atmost 2	0.608049	3.841466	0.4355	0.608049	3.841466	0.4355
		Rainfall	**Model**			
Hypothesised Number of CE(s)	Trace Statistic	Critical Value	Prob.	Max Eigen Statistic	Critical Value	Prob.
None	44.81819	29.79707	0.0005	24.01004	21.13162	0.0191
Atmost 1	20.80815	15.49471	0.0072	15.61997	14.26460	0.0303
Atmost 2	5.188185	3.841466	0.0227	5.188185	3.841466	0.0227
		Wind Speed	**Model**			
Hypothesised Number of CE(s)	Trace Statistic	Critical Value	Prob.	Max Eigen Statistic	Critical Value	Prob.
None	36.77980	29.79707	0.0067	23.79889	21.13162	0.0206
Atmost 1	12.98091	15.49471	0.1155	8.187313	14.26460	0.3600
Atmost 2	4.793599	3.841466	0.0286	4.793599	3.841466	0.0286

4.6. Vector Error Correction Model Results

The results of VECM are presented in Table 4.5.

4.6.1. Long-run Causality Results

The first target variable was the dependent (total weather-related losses) in all three models. To obtain the p-value of each dependent variable, the least squares method (Gauss-Newton/Marquardt steps) was used and the system equation was obtained. The results in Table 4.5 show that C1 is the coefficient of the models which denotes the long-run causality, with C2, C3, C4, C5 and C6 coefficients denoting short-run causality. Moreover, C1 is the speed of adjustments towards the long-run equilibrium. If there is long-run causality, this coefficient should have a negative sign.

Based on the above findings, C1 in all the models is negative; hence, it can be concluded that there is long-run causality between temperature, rainfall, wind speed, gross written premium, and weather-related losses. However, the p-value is only significant in temperature model and insignificant in the other two models. This means that the long-run causality or association in the rainfall and wind speed models is weak. Furthermore, the short-run causality between all independent research variables and weather-related losses was tested using the Wald test. The short-run causality test results are presented in the next section.

Table 4.5: VECM Results for Temperature, Rainfall and Wind Models

	Temperature Model			Rainfall Model			Wind Model		
	Obs Value	**t-statistic**	**Prob**	**Obs Value**	**t-statistic**	**Prob**	**Obs Value**	**t-statistic**	**Prob**
C(1)	-0.928564	-2.411864	0.0227	-0.510033	-1.515893	0.1408	-0.140365	-1.192198	0.2428
C(2)	4107889.	2.267229	0.0313	-241049.6	-1.386261	0.1766	-0.666889	-3.604326	0.0012
C(3)	-0.292969	-1.278632	0.2115	-0.467334	-1.883005	0.0701	-2535468.	-0.467606	0.6436
C(4)	-285512.6	-0.145024	0.8857	113014.1	0.865694	0.3940	0.032873	0.066097	0.9478
C(5)	0.115444	0.261775	0.7954	0.052618	0.108343	0.9145	617836.7	0.339341	0.7368
C(6)	372077.0	0.227580	0.8216	547344.9	0.303084	0.7641			
R^2	0.563430			0.468149			0.456118		
AR^2	0.485471			0.373176			0.381100		
Fs	7.227262		0.000187	4.929272		0.002323	6.08009		0.001113
DW	1.530947			1.707252					1.826606

4.7. Short-run Causality Results

Wald statistic results in Table 4.6 show the short-run relationship between each variable and weather-related losses. In the temperature model, the chi-square and corresponding p-values were significant, and the null hypothesis (no short-run causality) was rejected. Therefore, it was concluded that there is short-run causality between average temperature changes and total weather-related losses. However, the chi-square and corresponding p-value for both the rainfall and wind speed models were insignificant. Thus, the null hypothesis is not rejected, and it is concluded that no short-run causal relationship exists between average rainfall, wind speed, and total weather-related losses. The Wald test also showed that there is no short-run causality between gross written premium and total weather-related losses in all three models.

Table 4.6: Wald Test Result

Temperature Model	**Value**	**Probability**
F-statistics	4.180288	0.0258
Chi-square	8.360575	0.0153
Gross Written Premium	*Value*	*Probability*
F-statistics	0.276052	0.7608
Chi-square	0.552103	0.7588
Rainfall Model	**Value**	**Probability**
F-statistics	0.960861	0.3948
Chi-square	1.921722	0.3826
Gross Written Premium	*Value*	*Probability*
F-statistics	0.200894	0.8192
Chi-square	0.401787	0.8180
Wind Speed Model	**Value**	**Probability**
F-statistics	0.218655	0.6436
Chi-square	0.218655	0.6401
Gross Written Premium	*Value*	*Probability*
F-statistics	0.206528	0.8146
Chi-square	0.413056	0.8134

The R^2 in all the three models improved when VECM was used compared to regression analysis. The R-squared of 56% in the VECM for the temperature models as shown in Table 4.5 is much higher compared to the R-squared of 2.89% found in the regression model. This shows that changes in average temperature and gross written premium can collectively lead to a 56% change in total weather-related losses. Based on the study criterion in Section 3.5.1.1, 56% shows that the model variables have a moderate effect on weather-related losses, while 2.89% indicates that the joint effect of temperature and gross written premium on weather losses is still low. As a result, the R-squared values for the model based on regression and VECM range from 2 to 56%, and this is a low to moderate impact on the research criterion.

The rainfall model has an R^2 of 46.8% in the VECM model, which is higher than -7.4% in the regression model. The negative R-squared found is against the statistical norm. However, the researcher is of the view that this exhibits the complex relationship between rainfall and weather-related damages. The relationship is such that an increase in rainfall leads to a rise in water-related damages but a decline in drought-related damages. A decrease in rainfall could lead to a decline in water-related damages but a rise in drought-related damages. Furthermore, the limited availability of separate weather losses data specific to a weather event means that the joint effect of rainfall and gross written premium on weather losses, measured by R-squared, was difficult to determine. Although the regression R^2 in the rainfall model shows that the collective impact of the variables on weather-related loss is zero, the R^2 in VECM is positive and significant. This indicates that changes in average rainfall and gross written premium can collectively lead to a 46.8% change in total weather-related losses. R^2 for rainfall model in both regression and VECM analysis lies between 0 and 46.8%, and this is a low to moderate joint effect on the research criterion.

The R^2 in the wind speed regression model reveals that any changes in the model variables (wind speed and gross written premium) can cause a 1.9% change in weather losses. However, this value is lower than the R^2 of 45.6% found in the VECM. Thus, changes in average wind speed and gross written premium can collectively lead to a 45.6% change in total weather-related losses. R^2 from the regression and VECM tests range between 1 and 45.6%, which is low to moderate on the research scale. Overall, the regression and VECM R^2 of all the models range from 1 to 56%. This confirms a low to moderate joint effect of an explanatory variable on weather-related losses which is synonymous with the developing phenomenon. Therefore, in conclusion, it can be argued that the effect of climate change on weather losses is low to moderate in South Africa.

To affirm the soundness of the aforementioned results' autocorrelation, an analysis of autocorrelation was done. Autocorrelation can arise when there are similarities of repeating patterns within the time series data. This can lead to linear and unbiased results that are not efficient, in addition to the above autocorrelation. Durbin-Watson was used to evaluate any possible autocorrelation in all the regression and VECM models. The Durbin-Watson regression results in Table 4.3 and the VECM in Table 4.5 confirm that there is no autocorrelation. Moreover, the F-statistic and the corresponding p-values in Table 4.5 for all the models are significant. Taking all these factors into account, it can be concluded that models are good and useful.

4.8. Discussion and Analysis of Results

The previous section presented the results of the study which were proposed in Chapter 3. In this section, these results are analysed and discussed.

Table 4.7 presents a comparison of regression model results. Overall, it can be observed that there is a positive and significant relationship between climate factors (temperature, rainfall, and wind speed) and total weather-related losses. The findings revealed in Table 4.7 of the three models show that weather events are determinants or variables of climate change- (weather-) related damages. This is evidence that an increase in average temperature, rainfall, and wind speed will lead to a rise in weather-related losses, while a decrease in these factors will lead to a decline in weather losses. Based on these research models, it can be concluded that changes in weather factors can lead to changes in weather losses in South Africa. These findings are consistent with the reviewed literature in Chapter 2 in which empirical studies done in other countries proved that adverse changes in climate change factors such as temperature, rainfall, and wind speed influence weather-related losses or damages.

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Table 4.7: Comparison of Regression Models

Model	Statistically Significant	Correlationship	Direction of Relationship	Autocorrelation
Temperature	Yes	Yes	Positive	No
Rainfall	Yes	Yes	Positive	No
Wind Speed	Yes	Yes	Positive	No

The summarised results in Table 4.8 highlight cointegrating relationships or associations between climatic variables and weather-related losses. The long-run causality between temperature and weather-related losses in the temperature model was found to be very strong, while it was found to be weak in the rainfall and wind speed models. Overall, the existence of causality means that changes in temperature, rainfall, and wind speed will cause changes in the level of weather damages incurred. Using Wald test, the short-run causality relationship between temperature and weather losses was established. This demonstrates that an increase in temperature can cause a rise in weather-related losses. For instance, high temperature can lead to widespread fires and drought-related losses. Further to this, it should be understood that, in general, changes in temperature influence other weather conditions differently. Changes in temperature can lead to heavy rainfall, storms, or floods due to convection activity leading to an increasing in water-related damages. On the other hand, increasing ocean and surface temperature and less rainfall can lead to heat waves and drought, leading to an increase in drought-related damages.

The Wald test also showed that there is no short-run causality between rainfall and weather-related losses. This suggests that a change in the rainfall in the short run will not cause any change in weather-related losses in the short term. The weak long-run causality and absence of short-run causality in the rainfall model could be evidence that more time is required to observe or determine causality between rainfall and weather losses in South Africa. However, the fact that rainfall volume and intensity can result in different types of losses should also be considered.

An increase in rainfall might simultenously lead to a decline in drought- and fire-related damages,and .a rise in water (storm or flood) damages. Therefore, high rainfall can lead to lower drought-related weather damages, while lower rainfall can lead to less flooding or water-related damages. To support the above analysis, Cong and Brady (2012) indicated that the correlation between temperature and other variables such as rainfall can temporarily change based on the seasons. Therefore, the joint distribution of rainfall and temperature could be affected by possible interdependence between them (Cong and Brady, 2012).

In addition to the foregoing, the data used in this study did not separate rainfall-related damages from other weather-related perils such as droughts, wind damages, and lightning. The data available was in aggregate format only, presented as the total annual economic cost of weather-related events. The lack of separate data on precipitation or rainfall-related damage limited the opportunity to analyse the actual relationship between precipitation and water-related damages data. Moreover, the following factors that influence precipitation-related losses should be taken into account: temperature, intensity of rainfall, duration, volumes, nature of surfaces, land use (deforestation and afforestation), drainage system, and building conditions and designs. These aspects can minimise or exacerbate weather damages in the event of a disaster.

The Wald test also revealed that there is no short-run causality in the wind model. Change in wind speed in the short run will not cause any changes in the weather-related loss. The absence of short-run causality and a weak long-run causality between wind speed and weather-related losses could imply that changes in wind speed are not yet significantly influencing weather-related losses in South Africa. If further insinuates that South Africa is not yet experiencing those severe and frequent tornadoes and hurricanes that have caused significant losses in other parts of the world.

In summary, the weak long-run causality found in both the rainfall and wind speed models should not be underestimated. It actually provides an important indication or hints that some cause-effect relationship exists between rainfall, wind speed, and weather losses in South Africa. Overall, the aforementioned findings regarding the relationship between weather variables and weather damages point to the fact that global warming, changes in precipitation, and wind speed collectively or independently have a conspicuous impact on weather-related damages.

The results of the study provided evidence that there is a positive correlation between climate factors and weather-related losses in the context of South Africa. The findings also answered research questions that average changes in annual temperature, rainfall and wind speed levels lead to changes in insured weather losses in South Africa. The primary objective of the study was to find out if there is a significant relationship between climate change and weather losses. The model results have established that there is a significant positive relationship between climate change factors and weather-related losses in South Africa. The cointegration analysis proved that there is a long-run relationship between research variables and weather-related losses. The VECM further affirmed that there is a long-run causal relationship between weather variables and weather losses. Therefore, it can be inferred and concluded that changes in weather factors influence changes in weather-related damages or losses incurred by the local insurance industry. The study findings, in essence, confirm that there is some cause-effect relationship between climate change and weather damages in South Africa. However, the combined strength of the outcomes suggests that this is still an emerging or developing phenomenon.

Table 4.8: Comparisons of Cointegration Models

Model	**Cointegration**	**Long-run Causality**	**Short-run Causality**
Temperature	Yes	Strong	Yes
Rainfall	Yes	Weak	No
Wind Speed	Yes	Weak	No

The results for the goodness of fit of the research models is also summaried in Table 4.9. Despite the low-quality R-squared found in the regression analysis, the R-squared improved when Johansen cointegration and VECM tests were performed on the models. R-squared in this study explained the variance in total weather losses accounted by the model or each independent variable. It provided an estimated strength of the association between model variables but should not be viewed as an indication of the adequacy of a regression model. The R-squared for the temperature, rainfall and wind speed models found in the regression analysis was 2.89%, -7.4% and 1.9% respectively, while for the VECM model, it was 56%, 46.8% and 45.6% respectively. The regression and VECM models when analysed in conjunction with each other confirm that the R-squared in all the three models ranges from 0 to 56%. Based on the study scale or criterion in Section 3.5, the variables in these models have a low-moderate effect on weather-related losses. Overall, changes in average temperature, rainfall, and gross written premium collectively in each model do not cause more than a 60% change in total weather-related losses in South Africa. An R-squared of 60% is considered to be above average and adequate. These findings are crucial because they confirm the existence of an association between changes in climatic factors and weather damages or losses in South Africa.

In addition to the foregoing, the value probabilities of F-statistic in all the models as shown in Table 4.9 are significant. Furthermore, all the three models do not suffer from autocorrelation. These findings combined show that the proposed models are useful and valid, and the relationship between the variables was not found by chance. Therefore, based on these findings, the impact of climate change on short-term insurance weather losses in South Africa can be described as ranging from low to moderate. This level of impact found in this study also signals an emerging relationship between climate change and weather losses which should be monitored and further researched.

Table 4.9: Overall Comparisons of Goodness of Fit in Models

Model	Prob (F-statistics)	R-squared	Durbin-Watson
Temperature	Significant	Moderate	No Autocorrelation
Rainfall	Significant	Low to Moderate	No Autocorrelation
Wind Speed	Significant	Low to Moderate	No Correlation

The reliability test results exhibited in Table 4.10 show that all the three models did not suffer from serial correlation and heteroskedasticity. This means that the models are correctly specified – findings can be relied upon and are not misleading.

Table 4.10: Reliability of Models

Model	Serial Correlation	Heteroskedasticity
Temperature	No	No
Rainfall	No	No
Wind Speed	No	No

In Table 4.11, the results of normality tests indicate that data for total weather-related losses, temperature, and gross written premium is not normally distributed, whereas data for rainfall and wind speed follow a normal distribution trend in South Africa. Normality assumption is important, but some scholars (Gujarati, 2004) indicate that the absence of normality should not be a major concern because it is significantly influenced by the sample size. As the number of subjects in sample sizes increases or become greater than 30 or 40, there is likely to be a violation of the assumption. When the number of subjects in a sample becomes large, there is difficulty in obtaining a normal distribution. However, regression tests can still be conducted even when the data is not normally distributed (Ghasemi and Zahediasl, 2012). Normality is important, but its usefulness is dependent on the sample size. Therefore, validity of findings should not be dependent on normality test only but other tests such as heteroskedasticity (Lumley, Diehr, Emerson & Chen, 2002). Thus, in relation to this study, the number of subjects in the sample size was more than 30 and non-normality of some variables should not lead to biased or unreliable regression model results. Other tests such as heteroskedasticity and serial correlation were conducted and validated the models.

On the other hand, the non-normality distribution of weather losses indicates that trends currently occurring are outside the normally experienced weather losses. Further to this, climatic events generally have a low probability of occurring and a severe consequence leading to fat tail scenarios that show skewness. Climate change catastrophes are sudden, unpredictable and non-linear, hence often follow a non-normal distribution trend (Nordhaus, 1999, 2011). This suggests that weather or catastrophic damage in South Africa still follows a fat tail (low frequency but high impact). This observation is important for local insurers so that they can enhance their preparedness to tackle climate change losses.

Table 4.11: Normality Test for All Variables

Variable	Normal Distribution
Total Weather Losses	No
Temperature	No
Rainfall	Yes
Wind Speed	Yes
Gross Written Premium	No

4.9. Insurance Penetration Results for All the Models

Johansen cointegration test found that long-run relationship between gross written premium and weather-related damages was strong in the temperature model while weak in the rainfall and wind speed models. Moreover, the Wald test in all models showed that there was no short-run causality relationship between gross written premium and weather damage in all three models. Table 4.12 summarises the cointegration, short-run and long-run results.

Therefore, it can be deduced that insurance penetration in conjunction with climate change can influence weather-related losses in the long run. The absence of short-term causality indicates that in the short run, insurance penetration does not have an impact on weather-related losses. This further confirms a strong case that climate change is affecting insurance in South Africa.

Table 4.12: Cointegration Tests for Insurance Penetration

Model	Cointegration	Long-run Causality	Short-run Causality
Temperature	Yes	Strong	No
Rainfall	Yes	Weak	No
Wind Speed	Yes	Weak	No

The results in Table 4.13 bring out that there is a negative or inverse relationship between insurance penetration and weather-related losses in all models. Based on these findings, an increase in gross written premium might lead to a decline in weather losses, while a decrease might lead to a rise in weather-related losses. However, this relationship was found to be insignificant in all three models. These findings are inconsistent with reviewed literature and a prior expectation of this study which stated that an increase in insurance penetration leads to a rise in weather-related losses incurred by insurers. However, the analysis of these findings could be twofold. First, gross written premium was used as a proxy for insurance penetration so as to determine if changes in the insurance demand and market could lead to an increase in insurers' exposure to weather-related losses. Literature reviewed in this study showed that growth in insurance markets can influence the extent of weather losses received by insurers. The more the insurance policies held by insurers, the more the chances of receiving claims, including weather-related claims. Secondly, if weather-related incidents or losses increase, it might trigger a rise in demand for weather insurance, thus leading to an increase in gross written premiums. However, this analysis is inferred; therefore, further research regarding the relationship between insurance penetration and weather-related losses in South Africa is required.

The aforementioned findings are contrary to reviewed theories (Bouwer, 2011; Mills, 2005) which stated that an increase in insurance penetration might lead to a rise in weather losses. However, this could be an indication that high insurance penetration may not necessarily lead to an increase in weather-related claims. On the other hand, improvements in risk mitigation measures such as weather alerts, educating clients about weather risks, and encouraging storm-resistant buildings can help insurers to proactively reduce their exposure to weather-related claims likely to be received as markets grow. Therefore, it might not follow that if the insurance markets grow, weather-related losses will follow suit. Furthermore, the correlations established in all the models, although negative, show that market growth and insurance penetration play a role in influencing insurers' risk and exposure to weather-related claims. It stands to reason that insurance penetration should not be underestimated or disregarded when assessing the effects of climate change in South Africa. These findings provide a basis for future research on insurance penetration and weather-related damages in South Africa.

Table 4.13: Gross Written Premium in Regression Models

Model	Statistically Significant	Correlationship	Direction of Relationship	Autocorrelation
Temperature	No	Yes	Negative	No
Rainfall	No	Yes	Negative	No
Wind Speed	No	Yes	Negative	No

4.10. Summary

The study affirmed that climate change is influencing weather related losses (insured weather losses) in South Africa.The study found that temperature, rainfall and wind speed changes are significant in explaining changes in weather-related claims in South Africa. In attempting to explore and answer the secondary research objectives, the study established that (1) average changes in annual temperature levels lead to changes in weather-related claims, (2) average changes in annual rainfall or precipitation levels lead to changes in weather-related claims, and (3) average annual wind speeds lead to changes in weather-related loss.

The study findings showed that there is a correlation between climate change – represented by temperature, rainfall, and wind speed – and weather-related losses in South Africa. Therefore, the null hypothesis that there is a possible correlation between climate change and weather-related losses is accepted, and the alternative that there is no correlation between climate change and weather-related losses is rejected. The study also further revealed that a cause-effect relationship between these climate variables and weather-related losses exists. Although it is still difficult to quantify or understand the impacts of climate change on insurance in South Africa due to limited data, based on the literature reviewed and statistical findings of this study, there is evidence that variations in average weather conditions influence weather losses in South Africa. In general, the temperature model compared to other models presented the strongest case of the link between climate change and weather-related losses in South Africa.

Altogether the study results reveal that climate change is an emerging or developing risk and phenomenon in South Africa that could cost the insurance industry billions of rands in the long run. In general, emerging risks can be defined as new conditions or events that are still uncertain but can significantly affect a company's financial capacity, competitive or reputational position within the next five years. Climatic change risks are also new and are developing risks that are still difficult to understand and quantify (Barney, 2011; Flage and Aven, 2015). Leading reinsurers such as Swiss Re and Munich Re also define emerging risks as newly developing or identified risks that are still difficult to quantify, demonstrate cause-effect relationship, and can significantly affect an organisation or business.

The study findings should be a trigger to local insurers to begin seriously considering climatic risks. The industry should begin understanding the impact of weather patterns in conjunction with other economic factors that might influence the extent of weather losses. The statistical findings of this study should be the basis for future continuous research into predicting the relationship between climate change and weather-related losses so that the industry can be informed of possible trends in future losses.

The next chapter will discuss some implications of the research findings to the insurance industry. Furthermore, recommendations on how the industry can be involved in mitigating the effects of climate change losses and limit its exposure to weather-related losses will also be outlined.

CHAPTER 5: RECOMMENDATIONS, IMPLICATIONS AND CONCLUSIONS

5.1. Introduction

The local insurance industry has been reporting that weather-related damages or claims are increasing as a result of adverse weather conditions. Therefore, the purpose of this study was to scientifically establish if there is indeed a possible relationship between climate change and weather-related losses in South Africa. The findings in the penultimate chapter showed that there is correlation and some causality effect between climate change and weather-related losses.

The results of this study found that climate change is an emerging risk in South Africa and that there is a positive relationship between climate variables and weather losses. Thus, the conclusion can be made that generally an increase in temperature, rainfall and wind speed can lead to an escalation in weather-related losses. Although trends are still emerging or developing, evidence suggests that if climate change continues to worsen, weather-related losses are likely to increase in South Africa. If the association persists, then the effects of weather-related losses could be detrimental to the insurance industry if not properly anticipated and accounted for.

Unexpected increases in weather-related claims could threaten the sustainability and viability of the insurance industry. Although the impacts are not yet very severe and the trends are still developing, these research findings can assist the local industry to have a better understanding of the possible effects of climate change on weather-related insurance claims or losses. This information can assist insurers to step up their efforts in managing emerging weather-related risks. To insurers who are still sceptical, based on these findings, they should seriously consider climate change risks and take a critical role in supporting climate change risk mitigation and adaptation processes.

5.2. Research Implications

The impact of climate risks on the insurance industry will be dependent on the available insurance solutions and preparedness of the industry. Therefore, the industry should comprehensively incorporate climate change into its business strategy and enterprise risk management, and embed it in its corporate culture. The research results have the following implications for insurance companies in South Africa in improving their preparedness to tackle climate-related risk:

- carbon footprinting of insurance customers
- development of climate change risk insurance products and services
- climate change risk awareness to insurance clients
- increased climate change risk research partnership
- data sharing of weather-related losses
- incorporating climate change into insurance business operating models

The above implications will be explored and discussed. Theories reviewed in Chapter 2 showed that human activities have significantly contributed to contemporary global warming and climate change as a result of emission of greenhouse gases. Anthropogenic activities such as land use and pollution from business and industrial production activities are increasing greenhouse gases. If these processes continue, climate change is likely to worsen and lead to an increase in weather-related claims. In view of this, the insurance industry should champion and adopt good business practices to reduce the emission of greenhouse gases and carbon footprint. Insurance players and their clients should disclose their policies and risk mitigation mechanisms that seek to reduce greenhouse gas emissions and combat climate change.

Industry players should start employing climate-friendly ways in business operations and commit to disclosure of carbon footprint. The industry should set clear and measurable greenhouse gas emissions targets and goals. Disclosure should show the efforts undertaken by the business to manage climate change risk. Insurers play a crucial role as institutional investors, which can allow them to encourage disclosure of carbon footprint.

They can also encourage implementation of sustainable policies and structures to track and reduce emissions.

The insurance industry should also spearhead the development of products that encourage their clients to reduce carbon footprint and to develop new technologies that reduce carbon emissions. Green products solutions or initiatives should be introduced, such as pay-as-you-drive vehicle insurance, lower motor insurance premiums or discounts for hybrid vehicles, and premium discounts on climate-friendly buildings. Lower premiums and support for businesses that explore alternative energy sources and carbon credit-based initiative is another innovative way of an insurance product combating climate change. Insurers should encourage post-green claim settlement options such as upgrades to eco-friendly buildings and discounts for low-carbon vehicles. The market should consider introducing products such as green building insurance and allow customers to rebuild or replace lost property with environmentally friendly products that meet appropriate green standards.

Insurers can also begin to rate clients or businesses based on how they contribute to climate risks. This can be done by introducing a climate premium to discourage high carbon activity and fund climate mitigation initiatives. However, this requires the involvement and approval of regulators and policymakers. The industry should encourage and reward behavioural change that benefits both the policyholder and insurer in reducing climate change risks and moving to a lower carbon economy.

The rise in climate change risk, in general, indicate lack of effective governance, but the insurance industry should spearhead the reduction of carbon footprint and climate risk management across all industries. This is because it insures and protects the entire national economy. Perhaps there are still some of its stakeholders or clients that are not taking action against climate change because they know that in the event of weather-related losses, the costs from damages and clean-up will be passed on to the insurance industry. This approach might further exacerbate the industrys losses and costs. Further to this, the industry has the exposure and ability to influence risk reduction through risk-based pricing. Therefore, the insurance industry should use its broad links to different economic and social sectors to proactively engage and encourage its clients to reduce their carbon footprint.

Public awareness regarding the effects of climate change and weather damages should be improved. The local industry should play a significant role in improving climate risk awareness and offer incentives that encourage prevention and proactive risk management. Risk awareness can be increased by implementing risk-based terms or conditions and providing comprehensive climate change advice to clients. The South African short-term insurance industry should increase public communication campaigns about climatic risks, and encourage and advise clients to take preventive measures against weather losses. Such measures include waterproofing of buildings, building maintenance, fire suppression mechanism, and site inspections. Furthermore, proactively informing clients about weather changes and forecast will assist in reducing weather-related claims. The industry should adopt strategies to communicate climate risks and win support to manage weather risks and fight against climate change.

This research study highlighted that there is limited climate change research in the local insurance industry. Insurers should support climate change research, collaborate and partner with scientists and academic institutions to develop more refined models that predict the effects of climate change. They should also join knowledge platforms and initiatives such as ClimateWise and Principles for Sustainable Insurance, a global sustainability framework and initiative of the United Nations Environment Programme Finance Initiative (UNEPFI). Some insurance industry players such as Aon Insurance Brokers and Santam are already signatories to these global forums where climate change risks information is shared. The industry should be at the forefront of climate change research so that they understand the impacts of change in weather patterns on its businesses.

Insurers should also engage and partner with public authorities, regulators, and stakeholders and provide guidance or influence policies on matters such as land use planning, and designing of building codes and standards. This will encourage the building of storm-resistant buildings, flood defence mechanisms, and ensure that climate change is taken into account when new developments are undertaken. It is important for the industry and government to work together to improve adaptions and resilience to climate change. There is a need for integrated industry standards and guidelines regarding climate risk. The industry and government should partner up and come up with a coherent climate change policy to transition the economy to a low-carbon economy.

This study also showed that there is very limited, insufficient and incomplete information and records on insured weather-related losses. Local insurers should begin sharing information, expertise, and data relating to weather losses or claims. The systematic recording and keeping of weather-related losses or claims is required in order to be able to develop statistic models that can better predict future losses. Highly predictive risk models provide sufficient information to predict possible future weather patterns and losses, which is critical to developing adaption strategies. Climate change is an emerging risk and often difficult to determine its impact because its probabilities are still unknown; hence, sharing information is crucial. Given the above research implications, the section that follows will discuss research recommendations. The insurance industry should consider implementing these proposals so as to proactively manage climate change risks and minimise the effects of weather-related claims on the industry’s profitability, viability, and sustainability.

5.3. Research Recommendations

The research findings affirmed that climate change is already influencing weather losses in South Africa. The aforementioned research implications suggest that for the insurance industry to minimise its exposure to weather-related losses, it should ensure sound enterprise risk management. The industry should facilitate risk analysis and solutions to encourage behaviour that strengthens risk mitigation, resilience, and adaptation to weather-related damages. The emerging climate change risks are likely to change the way insurance business should be operated. In light of that, the next section will provide some recommendations on how the industry should deal with climate change risks and opportunities in order to remain viable.

Climate change risk affects all classes of insurance, both movable and immovable property. The viability of insurance business is based on the ability to underwrite profitably. Thus, there is a need to review the current pricing model and include weather-related risks. The insurance sector should incorporate climate risks at underwriting and pricing stage. Underwriting should include weather risk assessment and changing levels of exposure, as an unanticipated increase in weather losses can disrupt claims assumptions. Strategies such as implementing a peril rating can also assist insurers to charge sufficient premiums. Insurers should invest in powerful underwriting systems and software. A sophisticated underwriting system geocoded to policyholders' risk profile or address can predict possible catastrophic losses in vulnerable areas. This can help in estimating possible frequency and severity of weather claims before they occur. This will help insurers to prepare in terms of capital reserves, assessment arrangements, expertise, and staff required to handle or manage weather-related claims.

Claims management models should evolve and be aligned to emerging climate change risks. Insurers should use weather data to predict possible weather losses so that they can allocate claim reserves prior to losses. They should provide policyholders with weather data and educate them on how to prevent weather damages that can lead to a claim so as to minimise the frequency and severity of claims. The industry should also improve claim management systems and technologies to increase the capacity and ability to speed up claim processing in the event of a disaster. Consequently, insurers should on a continuous basis aggregate and use claims data to drive mitigation strategies.

The role of proactive and comprehensive portfolio management should come to the forefront in the insurance industry. It involves managing risk exposures, monitoring, protecting, and enhancing the book of business to enable growth and profitability. Knowing one's client's nature of assets and risk profile can also help insurers to recommend appropriate coverage, risk management strategies, and loss prevention techniques to minimise loss exposures. In an environment of increasing weather losses, insurers should have comprehensive knowledge of their book of business to make sure that they are aware of their exposures and manage them before losses occur.

Human and capital development focusing on climate risk management are also crucial. Since this an emerging risk, insurers might not have adequate personnel or experts trained in climate change and weather risks. Therefore insurers should begin training and development on how weather-related risks should be handled at both underwriting and claims stage. Furthermore, insurers should also begin building human capacity and invest in developing specialised expertise in the area of climate change. They should begin implementing staff and business stakeholder educational programmes on climate risk management. This will equip their employees to manage climate risk and advise clients appropriately. This will lead to a better understanding of climate change risks and minimisation of losses.

Unanticipated increases in weather losses can disrupt insurance statistical underwriting and claims assumptions. Insurers should begin reviewing their underwriting, claim models, and incorporate climate change. This will assist in proactively managing the insurer’s capital requirements and expected claim expenditure to ensure sustainability and viability. As economies transition to low carbon, insurers should seek opportunities to grow their business through insurance products that promote green energy projects, initiatives, and installations. They would want to educate their clients, partner up with researchers and public authorities to improve risk mitigation and resilience. Furthermore, the industry, as the carrier of weather losses, should come up with products and risk management strategies that measure up to the emerging climate risks.

5.4. Limitations of the Study

The poorly recorded data for insured weather losses in South Africa was a challenge. Insured weather losses data was incomplete as there was no data recorded for 17 of the 36 years under study. Therefore, total weather losses data was used as a proxy for insured losses based on the assumption that if these economic losses were insured, it would represent the claims burden to insurers. Future research should establish how best insurance companies can record, share, and publish such data so that insured weather losses can be used in future research models.

Total economic and insured weather losses were not classified to indicate the contribution of each weather peril (flood, storms, hail, drought, wind, and fire) towards the aggregate annual costs. This did not allow the researcher to analyse impacts of climate change on a specific class of insurance product such as cars, property, and agriculture; hence, the study provided a general impact of climate change on the short-term insurance industry.

The study used weather data from eight weather stations in seven provinces in South Africa. It should be noted that South Africa has a significant number of weather stations and nine provinces. However, the eight major weather stations in seven provinces are representative of the national weather data and cities (economic hubs) where insurance concentration is also high.

Empirical or related studies on the effects of climate on short-term insurance done in the South African context were difficult to find. The empirical studies carried out in other countries such as Nairobi, Netherlands, Norway, and Australia were reviewed. These pieces of research also targeted the short-term insurance sector. They utilised different quantitative research methodologies to examine the relationship between weather events and insurance claims or losses on certain classes of insurance. The common variables that were used in the empirical models were insurance claims data (dependent variable), temperature, precipitation, rainfall, and wind speed (independent variables).

The unavailability and incompleteness of insured weather data were also cited as a limitation. The findings from these studies indicated that weather events affect insurance claims. These empirical studies had a bearing on this study, as this study was modelled on these empirical studies and similar methodology. The conclusions of this study that weather variables influence weather-related insurance claims are consistent with the empirical evidence. This further bolsters the validity of the research findings. Although it can be concluded that climate change affects weather-related claims, it has also been noted that this is still an emerging phenomenon and more research is required. Therefore, the next section will provide a summary of possible research areas in the field of climate change and short-term insurance.

5.5. Suggestions for Further Research

This study brought to light that not much research has been done in the area of climate change and weather-related insurance in South Africa. This is still an emerging area of research; thus, more research is required. Further research should be conducted to determine the impacts of climate change on a specific class of insurance such as cars, property, and agriculture so as to be able to gauge the actual effects. This kind of research could also investigate how the insurance industry can underwrite or price weather risks so as to remain profitable and viable.

Further research could also focus on the relationship between insurance penetration and weather-related losses. This will provide the industry with greater insight into how economic and market growth is likely to influence their exposure to weather-related losses. It will also assist the industry to determine whether the increase in weather-related losses is a result of climate change or insurance penetration. In addition, future research can explore ways in which insurance companies can help in combating climate change and minimise weather-related damages in South Africa.

However, besides the above-highlighted possibilities of future research, since climate change is a fairly new field of research in the industry, some of the following areas could be explored by future researchers:

- Future research can explore the role that South African regulators and policymakers can play in strengthening the insurance industry's response to climate change risks.
- Further studies should be done in way that holistically determines challenges faced by the insurance industry in estimating weather-related loss estimation and how this can affect their business operations.
- More studies should be done in the following areas:

- opportunities and challenges of climate change risk management
- role of the insurance sector in climate adaptation, resilience, and disaster risk management
- finding appropriate collaboration models amongst communities, insurers, municipalities and government can improve climate risk management and resilience strategies

- Future studies should obtain weather data from more than eight weather stations so as to get a better analysis of climate change and weather patterns.

5.6. Conclusion

This study brought to light the apparent lack of research in the field of climate change and weather-related insurance in South Africa. This study can serve as a litmus test on the effects of climate on short-term insurance weather losses, to which other future related industry studies can be based on. This study has shown that climate change is already influencing weather damages in South Africa. The insurance industry is directly impacted by climate risks. Weather events from floods, storms, and droughts can translate into big losses that insurers have to pay out. It is therefore important for the local industry to be knowledgeable about developments in climate and weather, as the study has clearly brought out the effects of climate change on short-term insurance claims in South Africa.

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APPENDICES

Appendix 1: Stationerised Data

Modified	TWLS	AAT	AAWS	AAR	AGUP
1980	0	0	0	0	0
1981	2167500	24.134375	4.314285714	47.38541667	1342566
1982	2358750	25.891666	4.557142857	63.24479167	1652670
1983	21037500	24.396875	4.33452381	46.78541667	2020944
1984	573750	24.82708333	4.891666667	52.96458333	2499526
1985	4845000	24.51458333	4.455952381	46.70416667	2915750
1986	1020000	24.68541667	4.592857143	61.371875	3435127
1987	828750	24.59479167	4.295238095	55.95520833	3977563
1988	10455000	24.57708333	4.23452381	58.73541667	5371305
1989	4717500	23.1875	4.201190476	63.38125	6121587
1990	701250	23.69479167	4.357142857	59.30625	7037783
1991	6502500	24.25833333	4.448809524	49.39479167	7694080
1992	765000	24.33020833	4.548809524	59.79479167	9348245
1993	15108750	25.13541667	5.164285714	35.45416667	10385920
1994	637500	24.83541667	5.010714286	52.93854167	11133000
1995	3315000	24.31458333	4.9	47.5	12581000
1996	637500	24.378125	5.010714286	63.73958333	15055000
1997	2295000	23.75625	4.977380952	74.32604167	18065000
1998	0	23.809375	4.777380952	65.24166667	20737000
1999	2805000	24.73229167	4.763095238	59.12083333	22697000
2000	892500	25.05833333	4.68452381	48.84583333	21250000
2001	3570000	23.884375	4.545238095	70.846875	24670000
2002	637500	24.20416667	4.714285714	60.88958333	26538000
2003	765000	24.778125	4.486904762	52.7125	31444000
2004	637500	25.1177	4.476190476	40.85625	35643000
2005	765000	24.60416667	4.379761905	52.48229167	39970000
2006	1275000	24.92291667	4.49047619	47.96041667	45644000
2007	2741250	23.91770833	4.336904762	69.19270833	51355000
2008	2231250	24.909375	4.608333333	48.03541667	58099000
2009	7267500	24.790625	4.580952381	57.51145833	63500000
2010	701250	24.48020833	4.801190476	56.465625	69012000
2011	5482500	25.021875	4.717857143	55.759375	72479000
2012	318750	24.38120833	4.603571429	61.38958333	70407000

2013	5355000	24.85208333	4.83452381	43.928125	87000000
2014	7012500	25.20625	4.811904762	51.56666667	93148000
2015	1593750	24.66416667	4.529761905	47.47395833	100352000

Appendix 2: Disclosure Form for South African Weather Service

South African
Weather Service

ISO 9001 Certified Organisation

DISCLOSURE STATEMENT

The provision of the data is subject to the User providing the South African Weather Service (SAWS) with a detailed and complete disclosure, in writing and in line with the requirements of clauses 1.1 to 2.4 (below), of the purpose for which the specified data is to be used. The statement is to be attached to this document as Schedule 1.

1 **Should the User intend using the specified data for commercial gain, then the disclosure should include the following:**

1.1 the commercial nature of the project/funded research project in connection with which the User intends to use the specified data;

1.2 the names and fields of expertise of any participants in the project/funded research project for which the specified data is intended; and

1.3 the projected commercial gains to the User as a result of the intended use of the specified data for the project/funded research project.

2 **Should the User intend using the specified data for the purpose of conducting research, then the disclosure should include the following**:

2.1 the title of the research paper or project for which the specified data is to be used;

2.2 the details of the institution and supervisory body or person(s) under the auspices of which the research is to be undertaken;

2.3 an undertaking to supply SAWS with a copy of the final results of the research in printed and/or electronic format; and

2.4 the assurance that no commercial gain will be received from the outcome from the research.

If the specified data is used in research with disclosure being provided in accordance with paragraph 2 and the User is given the opportunity to receive financial benefit from the research following the publication of the results, then additional disclosure in terms of paragraph 1 is required.

The condition of this disclosure statement is applicable to the purpose and data requirements of the transaction recorded in Schedule 1 on page 2. This statement is effective from December 2015.

SCHEDULE 1

Please note: The South African Weather Service will only act upon customer requirements noted on this disclosure statement and not from any other correspondence.

FULL PERSONAL DETAILS OF USER

Full Names	
University/school/organisation	
Student Number (if applicable)	
Email address	
Cellphone	
Supervisor	
Project/Thesis Title	
Current registered degree (e.g. BSc)	
Expected finalization date (MMYYYY)	

The South African Weather Service reserves the right to request, at any time, from the student proof of registration for the Degree at the University.

THE PURPOSE (*Please indicate a detailed description of the purpose for which the data will be used)*

DATA REQUIRED *(Please include the weather elements (e.g. rain, temperature), place/s and time period)*

I hereby accept that:

- SAWS will be acknowledged in the resulting thesis/project or when published, for the data it provided.
- SAWS will be provided with a copy of the final results in printed or electronic format.
- The data received shall not be provided to any third party.

Signature of the User: Date:

(*Please sign the document and do not type your name in as this is a legal document and requires a signature*)

Appendix 3: UMI Form

STUDENT NUMBER: 51003007

UMI

M(I)
PAO
2001

MASTERS THESIS

PUBLISH ABSTRACT ONLY AGREEMENT

PERSONAL DATA

1. Last Name	First Name	Middle Name
Madzingira	Nyasha	

2. Year of Birth (Optional)	3. Country of Citizenship
1984_	Zimbabwean

Do not write in this space
Vol/Issue

4. Present Mailing Address

Street address:

27 Whittle Road , Groeneweide

City	State/Province	Postal code	Country
Boksburg	Gauteng	1459	South Africa

Future Mailing Address

Street address:

N/A

____

City State/Province Postal code Country

____

Effective date for future mailing address (mm dd yy) ______________________________

E-mail address: nmadzingira@gmail.com

____

MASTER'S DEGREE DATA

5. Full name of university conferring degree, and college or division if appropriate

University of South Africa,College of Economic and Management Sciences

____

6. Abbreviation for degree awarded

MCOM BMA

7. Year degree awarded

2017

TITLE/SUBJECT AREA

8. Enter the title of thesis. If thesis is written in a language other than English, please specify which language and translate title into English. Language of text: ____________________________________

Title:

The effects of climate change on short-term insurance claims in South Africa

9. Subject category of thesis. Please enter four-digit code from “Subject Categories” on following page.0505

10. Please append an abstract of no more than 150 words describing the contents of your thesis. Your completion and submission of this form through your graduate school indicates your assent to UMI publication of your abstract. Formulas, diagrams and other illustrative materials are not recommended for abstracts appearing in *Masters Abstracts International.*

Author Signature: ______________________________________ Date: ____________________

SUBJECT CATEGORIES Master's Abstracts International is arranged by subject categories.

Please select the one subject which most nearly describes the content of your dissertation.

THE HUMANITIES AND SOCIAL SCIENCES

COMMUNICATIONS AN D THE ARTS

Architecture............................0729
Art History..............................0377
Cinema..................................0900
Dance....................................0378
Design and Decorative Arts....0389
Fine Arts................................0357
Information Science................0723
Journalism..............................0391
Landscape Architecture..........0390
Library Science......................0399
Mass Communications...........0708
Music.....................................0413
Speech Communication.........0459
Theatre..................................0465

EDUCATION

General................................0515
Administration.......................0514
Adult and Continuing............0516
Agricultural...........................0517
Art.......................................0273
Bilingual and Multicultural....0282
Business...............................0688
Community College..............0275
Curriculum and Instruction...0727
Philosophy of.........................0998
Physical..................................0523
Reading.................................0535
Religious................................0527
Sciences................................0714
Secondary..............................0533
Social Sciences.....................0534
Sociology of..........................0340
Special...................................0529
Teacher Training....................0530
Technology............................0710
Tests and Measurements.......0288
Vocational..............................0747

LANGUAGE. LITERATURE.

AND LINGUISTICS

LANGUAGE

General................................0679
Ancient.................................0289
Linguistics............................0290
Modern.................................0291
Rhetoric & Composition........0681

LITERATURE

General................................0401
Classical...............................0294
Romance.............................0313
Slavic and East European...0314

PHILOSOPHY RELIGION

AND THEOLOGY

Philosophy.............................0422

RELIGION

General...............................0318
Biblical Studies...................0321
Clergy.................................0319
History of...........................0320
Philosophy of.....................0322

Theology...............................0469

SOCIAL SCIENCES

American Studies..................0323

ANTHROPOLOGY

Archaeology........................0324
Cultural................................0326
Physical...............................0327

BUSINESS ADMINISTRATION

General...............................0310
Accounting..........................0272
Banking...............................0770
Management.......................0454

HISTORY

General..................................0578
Ancient..................................0579
Medieval................................0581
Modern..................................0582
Black.....................................0328
Church...................................0330
African...................................0331
Asia, Australia, and Oceania...0332
Canadian...............................0334
European...............................0335
Latin American.......................0336
Middle Eastern.......................0333
United States.........................0337

History of Science....................0585
Law..0398

POLITICAL SCIENCE

General..................................0615
International Law and
Relations...........................0616
Public Administration.............0617

Recreation................................0814
Social Work..............................0452

SOCIOLOGY

Early Childhood 0518
Educational Psychology 0525
Elementary............................0524
Finance 0277
Guidance and Counselling ..0519
Health 0680
Higher 0745
History of 0520
Home Economics 0278
Industrial 0521
Language and Literature 0279
Mathematics 0280
Music 0522

Comparative..........................0295
Medieval................................0297
Modern 0298
African 0316
American...............................0591
Asian 0305
Canadian (English) 0352
Canadian (French 0355
Caribbean 0360
English 0593
Germanic 0311
Latin American......................0312
Middle Eastern 0315

Marketing 0338
Canadian Studies...................0385
ECONOMICS -
General 0501
Agricultural 0503
Commerce-Business...........0505
Finance 0508
History 0509
Labour 0510
Theory 0511
Folklore 0358
Geography 0366
Gerontology............................0351

General...................................0626
Criminology and Penology 0627
Demography...........................0938
Ethnic and Racial Studies 0631
Individual and Family
Studies 0628
Industrial and Labour
Relations 0629
Public and Social Welfare 0630
Social Structure and
Development 0700
Theory and Methods 0344
Transportation 0709
Urban and Regional Planning ..0999
Women's Studies 0453

THE SCIENCES AND ENGINEERING

BIOLOGICAL SCIENCES

Agriculture
General 0473
Agronomy 0285
Animal Culture & Nutrition ..0475
Animal Pathology.................0476
Fisheries and Aquaculture ..0792
Food Science and Technology 0359
Forestry and Wildlife............0478
Plant Culture........................0479
Plant Pathology 0460

EARTH AND ENVIRONMENTAL SCIENCES

Biogeochemistry 0425
Environmental Sciences 0768
Geochemistry 0996
Geodesy.................................0370
Geology...................................0372
Geophysics 0373
Hydrology................................0388
Mineralogy 0411
Paleobotany............................0345
Paleoecology 0426
Paleontology 0418
Paleozoology 0985
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Appendix 4: Editor’s Certificate

LET'S

EDiT

DECLARATION BY LANGUAGE EDITOR

28 November 2016

TO WHOM IT MAY CONCERN

DECLARATION: Language Editing of Dissertation

I hereby declare that I have edited the Master of Commerce (in Business Management) dissertation of NYASHA MADZINGIRA entitled "***THE EFFECTS OF CLIMATE CHANGE ON SHORT-TERM INSURANCE CLAIMS IN SOUTH AFRICA***" and found the written work to be free of ambiguity and obvious errors. It is the responsibility of the student to address any comments from the editor or supervisor. Additionally, it is the final responsibility of the student to make sure of the correctness of the dissertation.

Khomotso Bopape

Full Member of the Professional Editors' Guild

Professional EDITORS Guild

*Let's Edit is a **Level 1 EME B-BBEE Contributor** (Procurement Recognition Level = 135%)*

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Appendix 5: UNISA Ethical Clearance Certificate